In this Issue: Rebuilding the Austin Dam.—The New Filter Plant for Reading, Pa.—Tests of Street Flushing Machines.—Concerning Bridges over Navigable Streams.—Engineering Literature Supplement.

ENGINEERING NEWS

Founded 1874.
Volume 63. No. 15.

220 Broadway, NEW YORK, THURSDAY, APRIL 14, 1910.

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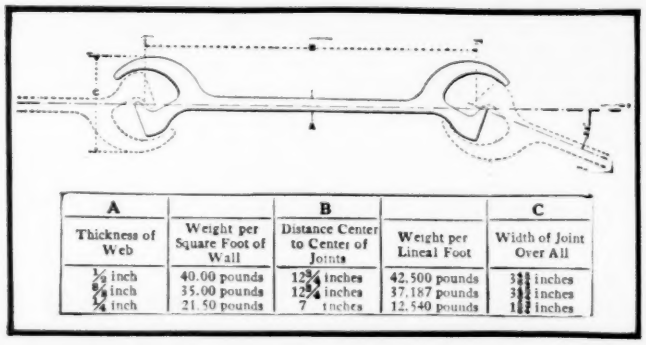

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A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

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Reforestation of the Marginal Lands of the Wachusett Reservoir; Metropolitan Water-Works Boston, Mass.*

By E. R. B. ALLARDICE,† Assoc. M. Am. Soc. C. E.

In the early development of the plans for building on the south branch of the Nashua River, at Clinton, Mass., what is now known as the Wachusett Reservoir, in which to store water for the supply of Greater Boston, the Metropolitan Water Board, largely through the efforts of one of its members, Dr. Henry P. Walcott, appreciated the fact that, unless systematically and scientifically studied and developed, the marginal lands of this great inland lake, which aggregate 3,380 acres, and in places extend back for half a mile, would become waste and valueless, a detriment to the purity of the water supply and a menace to the life of the soil. A small part of this large tract was made up of arable and pasture land which could be used for farming and grazing purposes; but, on account of the fact that manurial matters would result from such utilization, all idea of allowing cultivation and pasturage was abandoned as being even more of an injury to the purity of the water supply than the non-use of the land would be. There remained but one alternative: to reforest in some way the whole or a part of this reservation. To determine the kinds of trees to be used, methods of treatment and the various other questions of policy in this reforestation, the Board secured the services of Prof. J. G. Jack, of the Harvard Agricultural School, a recognized authority on sylviculture.

Professor Jack found an area made up of small parcels so varied in growth, soil and topography that hardly any two offered the same treatment. The arable lots, pastures and sparsely grown sprout lands offered a splendid opportunity for the practice of modern forestry. The more hardy sprout lands and timber forests could, by the expenditure of comparatively small amounts, be made paying property by cutting out the dead and undesirable trees, thereby giving more light, air and nourishment to the remaining hardy specimens, and assisting nature in the development of a valuable forest. The large areas grown to herbaceous plants, sedges and scrub oaks, of which a large percentage of the reservation was composed, which, therefore, could not be neglected in the solving of the problem, offered an excellent opportunity for experimental features in sylviculture.

Professor Jack recommended that the entire unforested portion of the reservation be planted with native white pines, making a self-perpetuating forest, which would ultimately provide a complete ground cover, requiring no artificial fertilizing or disturbing of the soil, and which would protect the waters of the basin from the direct contamination of manurial matters and soil washed from adjacent farms during heavy freshets or spring floods. The white pine was selected because of its almost universal adaptability to the various kinds of land and growth to be treated, *its freedom from leaves* [italics ours—Ed.], its rising value in the lumber market, and the ease, low cost and certainty of raising it to maturity.

An outline of the general policy adopted in the reforestation of the marginal lands of the Wachusett Reservoir, comprising as they did 1,090 acres of arable, pasture and light sprout land; 280 acres of thick sprouts and young, thin timber land; and 1,475 acres of heavy timber or forest land, was as follows: (1) To establish two forest nurseries, one on each side of the reservoir, for the raising from seed of coniferous trees, mostly native white pines, to form the ultimate or final forest, and of deciduous trees to act as fillers and aid in the final development of the conifers; (2) to plant all of the first-mentioned class of land with a mixture of white pines and hardwoods; (3) to underplant the second class with white pines, making what are hereafter termed "Improvement Thinnings in Young Pine Stands," as the growth of the pines demanded; (4) to make "Improvement Thinnings in Original Timber Stands," as opportunity permitted; (5) to clear and maintain a fire guard 40 ft. wide around the outside limit of the reservation, to serve as a protection against fires having their origin on abutting land; (6) to maintain some of the present, and build necessary additional, internal forest roads 15 ft. wide, making accessible all areas, and acting as secondary fire lines, dividing the entire reservation into lots containing from 15 to 30 acres; and (7) to clear and maintain a 50-ft. margin along the forested portion of the flow line of the reservoir, and to plant the inside half of it with white pine and arbor vitae closely spaced, forming an effectual screen or hedge to keep the greater part of the foliage from adjoining forests from being blown into the reservoir.

Fig. 1. 7-Year-Old White Pine Planted in Grass Land, August, 1905, When 4 Years Old.

Fig. 2. 9-Year-Old White Pine Planted in Open Pasture, When 3 Years Old. View taken April. 1909.

FIGS 1 AND 2. MARGINAL FOREST PLANTING, WACHUSETT RESERVOIR OF THE METROPOLITAN WATER-SUPPLY, FOR BOSTON, MASS., AND VICINITY.

Nurseries and Care of Seedlings.

Early in 1898, or about eight years previous to the completion of the reservoir, work was begun upon the preparation of the nursery on the north shore, containing 4.3 acres, and about two years later upon the one on the

*Slightly condensed from a paper printed in Jour. Assoc. Eng. Soc., January, 1910; the paper was read before the Boston Society of Civil Engineers, April 21, 1909. The paper as originally printed was accompanied by three half-tone views. We are indebted to the author for the originals of two of the views and for a number of additional photographs.—Ed.

†Supt. Wachusett Dept., Metropolitan Water-Works, Clinton, Mass.

south shore, containing 3.7 acres. In selecting the sites, attention was given to securing land comparatively level and well drained, composed of moderately fertile, sandy loam, free from weeds and stones. The nursery on the north shore was located on land formerly used for agricultural purposes and contained couch grass in large quantities, making it very expensive to prepare for and maintain as a nursery. The one on the south shore was located within the limits of a large area covered with

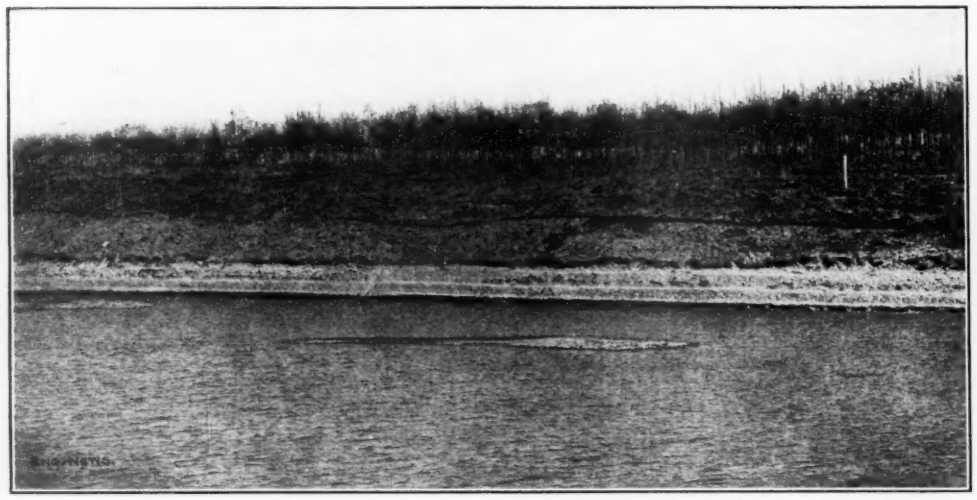

FIG. 3. IMPROVEMENT THINNING IN 10- AND 15-YEAR-OLD OAKS, MAPLES AND WALNUTS, WACHUSETT RESERVOIR MARGIN.

(The thinning was made in March, 1907, and the view was taken in April, 1909. The cleared marginal space along the water line may be noted.)

a stand of fifteen-year-old white oaks and chestnuts in a rather backward state, due to the ravages of forest fires. To prepare this area for nursery purposes, it was necessary to clear, grub, plow and harrow, at a cost of approximately $200 per acre.

SEED PLANTING.—As the methods adopted in the raising of coniferous and deciduous trees varied somewhat, they will be described here separately, first dealing with the white pines and other varieties of conifers.

During the month of May the area to be used was plowed to a depth of about 15 ins., and then leveled up by raking with heavy iron rakes. Beds were laid out 4 ft. wide by 40 ft. long, separated by paths 1½ ft. wide. The seed was prepared by soaking in warm water for about 48 hrs. and then covering with red lead to keep off birds and rodents. A "drill board" was used for shaping the drills in which the seeds were placed, consisting of a 1-in. board, 6 ins. wide and 4 ft. long (the same as the width of a bed), fitted with a handle on the upper side for convenience in handling, and with two grooved strips about 1 in. sq., running lengthwise of the under side of the board at each edge, the centers being 5 ins. apart, and the groove about ⅝-in. deep. For convenience in spacing the drills, this tool had at each end an outrigger or gage, consisting of a short piece of lath, through which was driven a small nail 5 ins. distant from the center of one of the grooves.

The seed-planting gang consisted of a foreman and four laborers, divided as follows: one drillman, two sowers, two coverers. The drillman formed the drills by forcing the molds or grooves of the dril-board down into the soil and rubbing it endwise. The two sowers, one of whom was the foreman, worked from opposite sides of the bed. The seed was placed in bottles fitted with wooden stoppers having a hole of the proper size to permit of one seed passing out at a time. The seeds were dropped on the ridge of the drill and fell into either channel. It was necessary to go over the same length three or four times in order to get a single continuous line of seeds. This method was found to be more economical than that of allowing the seeds to run freely from the bottle, which method sows too thickly. The sowers were followed by one of the coverers who sifted loam over the seed through a common ash sieve of ⅜-in. mesh until the drills were filled to the general level of the bed. The other coverer completed the planting by consolidating the loam with a board which he laid over the drills and pressed firmly into the ground.

It requires from two to three weeks before the sprouts appear above the ground and, during this time, great care has to be exercised to give the seed the proper amount of moisture. No particular rule can be laid down for this treatment, as it of necessity varies with the climatic conditions. During particularly dry seasons it was found necessary to cover the seed beds with a mulching of leaves and to water this mulch in the late afternoon about every second day. When the beds are mulched, daily examinations are necessary after the first ten days to ascertain when the sprouts have broken through, at which time the mulching should be removed. The ideal condition is that in which nature meets all the requirements and the beds or seeds demand no artificial treatment. Unfortunately, this condition rarely if ever continues for any length of time and it therefore becomes necessary to give almost constant attention to the beds from the time the seeds are planted until the sprouts break through the ground.

During the life of the seedlings in the seed beds (one year) they had to be given considerable care to prevent "damping off." This care consisted principally of screening and watering. Light lath screens about 4 ft. sq. supported on stakes about 1½ ft. above the surface of the ground were used, being manipulated as the weather conditions demanded. If the season was excessively dry, it was necessary to mulch the seedlings with dead leaves and water about three times a week.

TRANSPLANTING.—The seedlings having been in the seed beds one year, the next step was to transplant them into "Transplant Beds," where they were spaced about 4 ins. apart in rows 6 ins. apart and left from one to three years. In doing this work a gang composed of a foreman, one lifter, three sorters and counters, one pruner, one helper and eight planters was found convenient.

With a common garden spade the lifter removed the trees from the seed beds and they were sorted, counted, pruned and puddled. When the seedlings were taken from the seed beds they were first sorted, separating the strong and weak specimens. Then the long, fine, feathery roots were cut off at the bottom of the stocky part with a butcher's cleaver. The next step was to cover the pruned roots with a thick puddle, prepared by thinning heavy swamp muck to the consistency of thick gruel, after which they were immediately heeled into the ground ready for the planters.

The transplant beds were prepared in the same manner as the seed beds, and the plants or trees were placed in them by means of a common mason's trowel. A good planter should plant about 3,000 trees per 8-hr. day. While in the transplant rows the only care necessary in the summer time was to keep the beds free from weeds, which was done with small hand cultivators. During our treacherous New England winters we are very liable to experience short heavy thaws, which penetrate the ground to a depth of 3 or 4 ins. and heave the young transplants out, especially if they were transplanted the previous fall, as the roots do not have time to become well established before being exposed to this severe treatment. When this happens, they must be immediately pushed back into the ground or they will be frozen to death. This work should be done as rapidly as possible because of the liability of a freeze setting in at any time. Very little attention is given while pushing the seedlings back into the ground to keep from bending or crooking the small stems, as the seedlings are being raised for our own use and their value does not in any way depend upon their appearance. So long as nothing is done to injure the growth of the tree, our requirements are met. Caring for the seedlings at such times is given much more attention, however, by nurserymen, as their appearance is quite a factor to their value.

FIELD PLANTING.—Our practice has been to divide the work about equally into spring and fall planting, and time fails to show any difference in the results obtained. Most of our plans have called for the planting of from 50 to 100 acres of ground in both spring and fall, the former taking place immediately after the frost left the ground and before the trees began to grow, while the fall plantings have generally been made after the fall buds had set, depending largely upon the season. One planting, however, was made in August, and that, although experimental, proved a decided success, in spite of the fact that the trees were four years old and the season immediately following extremely dry. During the following fall these trees suffered some kind of a shock which apparently killed them, the needles all turning brown, but they have since recovered and are now among the finest stand we have.

Planting gangs are composed of a foreman and about thirty men, five of whom are engaged in the nursery preparing the trees for the field in the same manner as for transplanting. The field part of the gang is divided into pairs, one man making the hole for the tree with a common mattock, the other placing the tree and compacting the earth firmly about it. The work is very interesting because of its simplicity and rapidity. The men are lined up in pairs in a diagonal position on the field, the leader with a mattock and the planter with a pail filled with about 100 trees. The first pair are shown a previously established line, stone wall or fence to guide them, while the others in succession, with the aid of one man especially assigned to the duty, plant parallel to and at a given distance from the preceding pair. The spacing in the rows is done by pacing. In the easiest plantings, such as open pasture or light grass land, the leader opens the ground with two strokes of the mattock, the first one being made with the axe blade and the second with the grub blade, cutting the ground just below the top of the first cut. With the grub blade of the mattock in its position at the end of the last stroke, the ground is pulled up and back while the planter places the tree in the hole. While the leader is pacing the distance to and preparing the next hole, the planter compacts the earth about the tree by forcing his heel into the sod. With a well-organized and experienced gang, a pair of men will plant about 2,000 trees in a 9-hr. day, or 1,000 trees per man, at a cost, including the nursery work, of about $3.25 per 1,000 trees.

Great care has to be given during this work to see that the roots of the seedlings are not "root bound" when placed in the ground. The covering of the roots with thick puddle naturally binds them together and, unless they are shaken out before being planted, the growth of the tree will be greatly retarded.

The above description and rate are applicable only to first-class planting areas, the methods varying and the cost increasing according to the nature of the ground. For instance, in heavy grass land it is necessary to remove the sod from an area about 6 ins. square, requiring three or four strokes of the mattock, before making the final hole as described above. In sprout land or grown-up pasture the speed is necessarily slower because of the interference of the trees. The maximum cost per 1,000 trees was $7.87.

Thus far we have considered and described the methods adopted in the raising of white pine and other varieties of coniferous trees from the time the seed was sown until they were placed in their final location in the field. Remarkably successful results with these varieties have been obtained, 90% of the trees placed in the field having lived, and great credit is due the men who outlined and instituted the system. We, as engineers, are frank in admitting that at times we learn fully as much from our unsuccessful ventures as we do from the successful ones.

I now wish to describe the methods pursued in that branch of our forestry work which have largely failed, namely, the raising of hardwoods, the principal varieties of which were maple, oak, chestnut and walnut.

The general method of preparing the ground and seed was similar to that used in sowing the conifers, except that the different varieties of seed were soaked for varying periods, dependent upon the variety and quality of stock. The drills into which the seed were sown ran lengthwise of the beds instead of across and were single drills 6 ins. apart instead of double ones. After remaining in the seed beds for one year, they were transplanted directly into the field after being culled, pruned and puddled in a manner similar to the conifers. Experience and time revealed the fact that the hardwoods thus planted were, almost to a tree, dying and, as the nursery was at this time filled with hardwood seedlings, it became necessary to change our method if we wished to obtain satisfactory results. The reason for their almost complete failure was first attributed to the age (one year) at which the seedlings were transplanted into the field, so it was decided to transplant the seedlings into transplant beds, having the rows 12 ins. apart with the trees 6 ins. apart in the rows, thereby giving sufficient room for development for at least two years more. In transplanting to the transplant beds, the same general treatment was given the seedlings as described in transplanting the conifers. During the season following transplanting, when the only care given was to water and keep the beds free from weeds and witch grass, the trees seemed to prosper and pick up finely, but the next spring the fact was revealed that a great many (perhaps 33%) were dead, and each succeeding spring found us with fewer trees, and these very weak, sickly specimens. These facts led us to believe that the failure of the one-year-old hard-wood seedlings planted in the field was not wholly due to their age, but more to their treatment and the soil in the nursery. A careful study of this soil, the condition of the roots in the fall and spring, and the treatment given the seedlings, led us to believe that the true cause of this failure lay in the character of the soil.

The kind of soil recommended for the nurseries was, as

stated previously, well-drained, moderately fertile, sandy loam, free from weeds and stones. After due consideration and study, the nursery on the north shore was established and the raising of pine seedlings begun. During the early stages it was discovered that the soil in this nursery was not particularly well adapted to the needs of the pines; so when the time for planting hardwood seeds arrived, this nursery was chosen for them and a new one established on the south shore for the raising of the

FIG. 4. 9-YEAR-OLD WHITE AND SCOTCH PINES AND SUGAR MAPLES ON WACHUSETT RESERVOIR MARGIN.

(Planted in spring of 1902, when pines were 3 years and maples were 1 year old. View taken April 1, 1909.)

pines. While the nursery on the south shore was an ideal one for the pines, it did not seem at all adapted to the requirements of the deciduous trees, while the soil in the other nursery did; therefore they have been used for conifers and hardwoods, respectively. The continued working of the soil in the hardwood nursery has revealed the fact that it contains a large proportion of shale, and it is to this that we attribute the failure.

During the winters since the hardwoods were planted, there have been one or two extremely heavy thaws which have partially uprooted the seedlings and in so doing stripped the small fibrous growth from the delicate tendrils, thus robbing them of their means of securing nourishment from the soil, and weakening them to such an extent that they were unable to withstand the freeze which followed. This theory is borne out by the fact that the trees having one main tap root (ash and locust) have withstood the exposure and thrived surprisingly well.

COMPOSITION OF PLANTINGS.—Thus far we have considered and explained the work so far as the methods of raising forest trees from seed and planting them into the field are concerned. Now let us deal with the make-up or composition of the seedling stands.

The original condition of the area to be treated being so varied, it was necessary to vary the composition of the artificial stand to meet the requirements of the individual lot. In the main, the plantings comprised white pines planted 10 ft. by 10 ft. apart, using oaks, chestnuts and maples as fillers, making the final stand with trees 5 × 5 ft. apart, the theory of this composition being that the hardwoods, growing so much faster than the pines, would thrash their young, tender limbs, thereby forcing them to grow upwards and develop a long, straight, clear log. This type of planting required 435 pines and 1,307 hardwood trees per acre and was used in arable, open pasture and light sprout land.

In the thick sprout and young, thinly-grown timber land, the pine seedlings were used to underplant the sprouts and interplant the open areas of the timber land. No set rule could be established for the spacing in this type of planting, as it varied with the existing growth. It would be safe to estimate from 500 to 800 trees per acre.

The first plantings were made during 1902, and from then up to the time that the failure of the hardwoods (1906) was discovered, the mixed type of planting was used. Since that time no hardwoods have been planted and the pine seedlings have been spaced 6 × 6 ft. apart in the field, this close spacing being adopted so that the limbs might thrash and kill each other, thereby obtaining the same results as with the mixed stands. This spacing required 1,210 trees per acre.

Improvement Thinnings.

We are told by forest experts and advocates that the pines need no attention after planting in the field until such time (about fifteen years afterwards) that the first thinning is necessary. This is true only so far as it deals with the planting of arable and open pasture land. One of the main arguments in favor of reforestation is that sprout and scrub lands may be converted into paying timber land by simply raising and planting the young trees. While I would not go on record as making any statement detrimental to the growth and advancement of the great industry of forestry, which is one of the foremost questions before our country to-day, yet I believe that, for the good of its development, it is necessary that this article contain all the facts as we have found them.

A large part of our reservation was covered with sprout and scrub growth, which has been and was originally intended to be underplanted with pines. About the only requirements for a vigorous growth are plenty of light and fresh air, and we all know, if only from occasional observation, that neither of them is found under such a ground cover. When planted in this kind of land, the pines grow up in a rather delicate condition, until their tops encounter the low-lying limbs of the surrounding growth. At this stage it is absolutely necessary to give them assistance if they are to survive. This we have found can be done for about $6 per acre, the method being to cut out all growth which is in any way, at this time or within the next few years, liable to stunt or kill the trees. The wood cut at this time has very little value even as cord wood on account of its small size, so it has been piled in windrows between the pines and left to rot, or disposed of for pea brush.

In doing this work due care is taken to preserve all valuable specimens of trees and to leave sufficient fillers of any nature whatever which will act as crowders to the pines.

Our one aim in all branches of the work thus far described has been to secure ultimately a sound, healthy stand of pure white pines, having from 250 to 350 trees per acre.

As considerable of the reservation was originally covered with timber stands varying from fifteen to fifty years of age, which had been left to take care of themselves for years past, it has been our practice to make improvement thinnings in them by cutting out the poor, weak specimens, and such of the hardy ones that were overtopping or crowding the young vigorous growth. In a stand of twenty-five-year-old maples and chestnuts, intergrown with gray birch, a thinning such as described above, which included the cutting out of all the birches, was made at a cost of $28.50 per acre. There is considerable revenue derived from the sale of cordwood made at this time, which has, under the most favorable conditions, paid for the labor. Undoubtedly additional thinnings will have to be made from time to time, taking out the weak and overtopping specimens, which in all probability can be done at a profit. By this method the maximum returns per acre will ultimately be secured.

Fire Protection.

Among the greatest dangers to the forests are fires and, in order to prevent their spreading to or from abutting property, and to provide a line of defense on which to fight them, a "fire guard" 40 ft. wide has been cut around the entire outside limit of the marginal lands of the reservoir. There is also a network of "forest roads" 15 ft. wide throughout the reservation, which acts as supplementary fire protection. The brush and weeds are cut from these two protective systems once every year.

A double furrow has been plowed along that portion of the fire guard where there was no stone wall to check the advance of creeping fires from neighboring property.

On holidays and Sundays, during the dangerous seasons of the year (only spring and late fall), men armed with fire extinguishers patrol the reservation to protect it from the ravages of forest fires.

Thus far no serious fires have occurred, though several have started which would have caused great damage but for the effectual protection given.

Reservoir Marginal Screen.

In order to have an effectual screen along the forested portions of the shore of the reservoir, which would prevent the foliage from the deciduous trees from being blown into the reservoir, three rows of white pines spaced 6 ft. apart each way, and two rows of arbor vitae 2 ft. apart, trees 3 ft. apart in the rows, have been planted on the back half of the 50-ft. reservoir margin. The greater proportion of the arbor vitae have failed, probably because of having been planted in the field when too young (two or three years old) to endure the severe exposure which prevails along the shore of the reservoir.

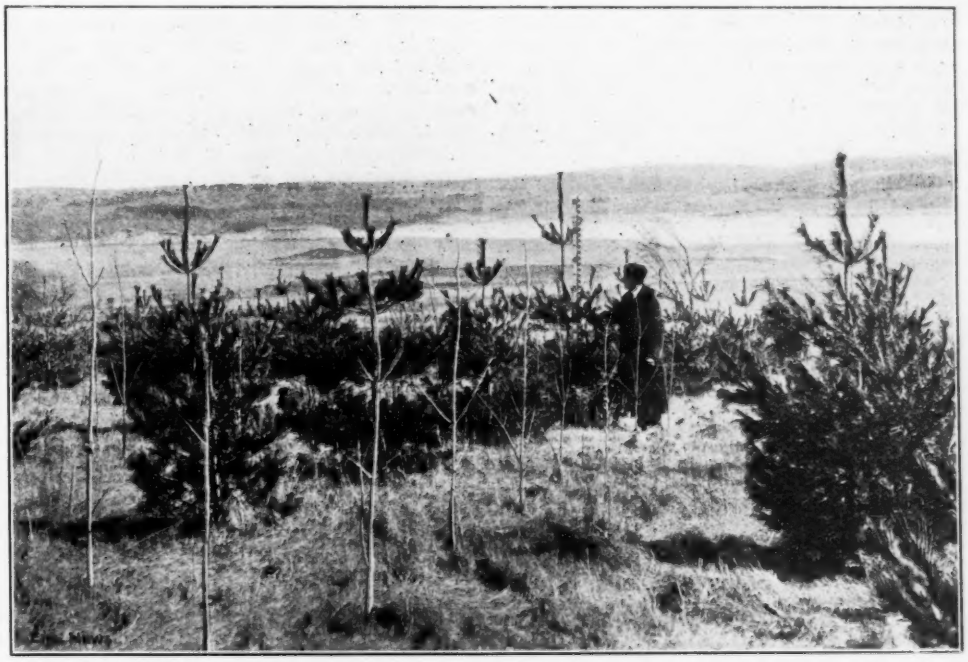

FIG. 5. 8-YEAR-OLD WHITE PINES AND 6-YEAR-OLD MAPLES ON WACHUSETT RESERVOIR MARGIN.

(Planted in spring of 1903, when pines were 3 years old and maples were 1 year old. View taken April 1, 1910.)

At the time of sowing the arbor-vitae seed, a much larger quantity was used than was needed for this purpose, so the seedlings which remained after the planting was done have been transplanted into transplant beds in rows 12 ins. apart with the trees 6 ins. apart in the

rows. These trees have now been in the transplant beds two years, during which time they have been pruned once, with the result that we now have available a sufficient number of strong hardy specimens with which to replant the entire 32 miles of flow line. This will require about 113,000 trees, spaced 3 ft. apart in rows 2 ft. apart, breaking joints, so to speak.

The table following shows that it costs about $15.40 per 1,000 trees, or $19.20 per acre (1,390 trees per acre), to raise the trees from seed, prepare, plant and protect the lands planted through the time of the final

STATISTICS RELATING TO REFORESTING WACHUSETT RESERVOIR LANDS.

Work Accomplished to Dec. 31, 1908.

Total area of nurseries	8.0 acres
Total area planted	1,330 acres
Total number of trees planted: coniferous	948,000
deciduous	902,000
Total length of reservoir margin planted	32.0 miles
Total length of fire guard cleared and maintained	20.8 miles
Total length of forest roads cleared and maintained	30.0 miles
Planted area thinned	488 acres
Original timber stands thinned	209.0 acres

Table of Costs.
(Wage rate, $1.75 per 8-hr. day.)

Nurseries:	
Clearing nursery on south shore	$200 per acre
Maintenance of nursery, first-year seedlings	$1.50 per 1,000 trees
Maintenance of nursery, second and third year seedlings	$1.75 per 1,000 trees per year
Plantings:	
Clearing areas preparatory to planting	$4 per acre
Transplanting seedlings from nursery to field	$5.25 per 1,000 trees
Transplanting seedlings from nursery to field	$5.50 per acre (6×6 ft. planting)
Improvement thinnings:	
Among planted trees	$6 per acre
In original timber stands	$20 per acre
Fire Protection:	
Clearing marginal fire guard 40 ft. wide	$150 per mile
Maintaining marginal fire guard	$27 per mile per year
Clearing and grading forest roads 15 ft. wide	$120 per mile
Maintaining forest roads	$8 per mile per year
Maintaining fire patrol	$100 per year

Reforestation—Summary of Costs on Planted Pine Stands.
(Wage rate, $1.75 per 8-hr. day.)

Item.	Per 1,000 Trees Planted.	Per Acre Planted.
Preparing nurseries	$0.40	$0.60
Seedlings (1 year)	1.50	2.25
Transplants (2 years)	3.50	4.50
Preparatory clearing	3.00	4.00
Field planting	5.25	5.50
Clearing 40-ft. fire guard	0.75	1.00
Clearing 15-ft. forest roads	1.00	1.35
Maintaining 40-ft. fire guard (per year.)	0.14	0.19
Maintaining 15-ft. forest roads (per year)	0.06	9.09
Maintaining fire patrol	0.02	0.03
Improvement clearing	4.25	6.00

planting in the field; that it costs about 22 cts and 31 cts per year, respectively, to maintain efficient fire protection; that in sprout and scrub land it costs about $4.25 and $6, respectively, for an improvement thinning, which will probably have to be made twice during the first ten years, after which time the trees should care for themselves.

The credit for the marked success of this work is here given to Dr. Henry P. Walcott, of the Metropolitan Water and Sewerage Board, and president of the Massachusetts Forestry Association; Frederic P. Stearns, Chief Engineer of the Metropolitan Water-Works during its conception and the greater part of its development, and Hiram A. Miller, who, while engineer of the reservoir department of the Metropolitan Water-Works, had charge of the planning and beginning of this work.

Conclusions.

While the methods adopted have, in general, given very satisfactory results, some lessons have been learned which should be of considerable assistance to promoters of similar schemes.

(1) As stated above, the character of the soil in the nursery used for the raising of hardwoods seems to be the cause of their failure, and, therefore, it would seem to be a warranted expense, when selecting nursery sites, to employ an expert in soil anaylsis to determine the location for the nurseries required. The United States government has such men whom it is only too glad to furnish at little or no expense to the owner or promoter.

(2) The order in which the various classes or types of the land were planted does not, at the present time, seem to have been entirely fortunate. The first land planted was the arable and pasture; second, the light sprout; and last, the thick sprout, scrub and thin timber land. If left to my judgment, based as it is on the lessons learned in the development of this reservation, this order would in a great many cases be reversed. In so doing the stands requiring thinning within the first five years would be planted first, and those requiring little if any thinning for at least fifteen years would come last. Of the type planted first, the heavy grass land proved especially hard for the pines, for during heavy snowstorms the long dead grass became matted down upon the small trees, leaving them covered with a heavy thick mat through which very little light could penetrate, or the young trees force themselves. On such areas it was necessary to mow around the young trees or, by means of a common dung fork, to break open this mat and free the tree. If these areas had been mowed for a few years before planting, the grass would have naturally run out and become so weak and thin that it could have done no harm to the seedlings. This matter of the order in which various classes or kinds of land should be planted is, it seems to me, a very important one, and the person who, without experience, plans to take up the work of reforestation would do well to consult the state forester, who has a competent corps of assistants ever ready to give suggestions and help in making up planting plans.

While the development of the area planted has not advanced far enough to allow of any estimate being made of the ultimate cost of the final quantity of lumber to be marketed, it has proven beyond a doubt that a scheme of reforestation along the lines described can be successfully carried out without more than slight assistance from experts; for, aside from having the general policy outlined, this work was planned and carried out by men inexperienced in this work.

Another fact which, to say the least, has not been beneficial to the work is that the personnel of the force doing the work, from the engineer or forester in charge down through the ranks, has so changed with the advance and completion of the work on the reservoir that there now remains but one man, a foreman, who was on the work at its beginning.

These facts only go to prove that with a small amount of professional advice and an intelligent study of nature, satisfactory results can be obtained.

Some people may censure the promoters of this work for entering upon a project which would be in part experimental and which would require the expenditure of considerable money before any returns would be received therefrom, but by those who have the interests of forestry at heart they will be commended for thus having taken steps to turn their own waste and valueless land to the most economical good, creating a shelter for the native wild animals and birds and beautifying an otherwise rank, repulsive and unsatisfactory wilderness, besides establishing a source of reference where all those interested either in forestry pure and simple or forestry as a branch of our large water supplies may look for information which we hope will materially aid in the final reforestation of our own great country.

Proposed Harbor Development at Milwaukee, Wis.

The city of Milwaukee, Wis., is contemplating extensive enlargement and improvement of its harbor facilities, and the city council recently engaged Mr. Isham Randolph, M. Am. Soc. C. E., consulting engineer, of Chicago, to investigate and report upon the question of harbor development. For a copy of the report we are indebted to Mr. Charles J. Poetsch, M. Am. Soc. C. E., City Engineer and President of the Board of Public Works.

The city has a large shipping traffic, which at present is accommodated in the rivers, where it is hampered by insufficient depth of water and by an increasing number of drawbridges. Mr. Randolph proposes the establishment of a new harbor on the lake front. The plan provides for a number of parallel piers and slips south of the river mouth and on the east (or lake) side of the narrow peninsula (known as Jones Island) which lies between the Kinnickinnic River and the lake. These would be protected by breakwaters, to be built by the U. S. Government at a total cost of about $2,170,000, and enclosing an area of about 1,550 acres. The present breakwater would be extended 1,800 ft. and a new southern breakwater built with a total length of 8,000 ft.

Previous to the construction of the breakwaters, however, a considerable development is possible on the west or river side of the peninsula, where slips, piers and a large basin can be constructed. Railway connections and a freight belt railway around the city are provided for. A bridge from the city to the peninsula is out of the question, and a ferry transfer is proposed until such time as the business may demand a tunnel connection.

The docks or piers are to be of the wharf type, and the design calls for reinforced-concrete piles (36 ft. long), caps and flooring (36 ft. wide) at an estimated cost of $45 per lin. ft. of dock. The material removed at points requiring excavation would be used as filling at other points, and part of this could be handled by pumping. The total cost for excavation, filling, and piers is estimated at $2,953,000, with $394,000 additional for railway tracks. Not all of the work need be constructed at once. For the first division of the work, the cost of construction, tracks and warehouses complete is estimated at $3,576,750. The buildings designed include two types of two-story warehouses at $334 and $409 per lin. ft., and a one-story type of freight shed at $155 per ft. The grain elevator on one of the lake-front piers would have a capacity of 2,000,000 bushels and its cost is estimated at 20 cts. per bushel, or 30 cts. per bushel including the complete machinery equipment. The cost of the belt railway is estimated at $1,029,800.

In many ways the present conditions are similar to those at Chicago, which have been described in our columns with reference to the proposed harbor developments at that city. Milwaukee has three rivers which form its inner or commercial harbor, supplemented by a number of slips and canals. A report made last October by Major C. S. Bromwell, U. S. Engineers, points out that the rivers are narrow and tortuous and are spanned by numerous bridges, so that their navigation by large steamers is slow, dangerous and expensive. With the increasing size of the lake steamers the facilities of the harbor are now inadequate, resulting in congestion and delays. The rivers are so narrow that large vessels moored at the wharves to receive or discharge cargo seriously interfere with the passage of other vessels.

During the past ten years the city's lake commerce has nearly doubled, and is now about three times as great (in tonnage) as its rail commerce. The average size of vessels calling at this port has increased also, since the number remains almost stationary in spite of the increase in commerce. There are several lines of package freight steamers between Milwaukee and Buffalo (in connection with eastern railways); also several coasting lines, two daily lines across the lake (for passengers and freight), and two car-ferry lines. The greater part of the lake commerce is carried by large bulk-cargo steamers, and the principal commodity is coal, of which over 4,000,000 tons were received in 1908. The shipments of grain from Milwaukee in 1908 amounted to 28,618,509 bushels, of which 13,300,000 bushels were shipped by water and the balance by rail.

The city's harbor committee favors municipal ownership of the harbor and its facilities, and this view has been endorsed by Major W. V. Judson, U. S. Engineers, in a communication to that committee.

Tests of Street Flushing or Washing Machines, Department of Street Cleaning New York City.

By E. D. VERY.*

The constant search for improved methods of street cleaning has brought forth no better device than the pavement flushing or washing machines which deliver the water to the surface of the pavement in proper shape, at the correct angle and with effective pressure. Though all are looking forward to a machine which will operate successfully on the suction principle, no tests are available which would warrant the adoption of such a machine by street cleaning officials. An attempt was made to bring out a test of suction machines as an addition to the flushing tests described in this article, but the action came so late that no results were obtained which can be used this year. The test, here described was the result of the action of Commissioner W. H. Edwards who was instrumental in the introduction and passage of an act of the New York State Legislature which empowered the Commissioner of Street Cleaning to enter into a contract for from three to five years "for the cleaning, sprinkling, flushing or washing with

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machines of the streets and avenues of New York City."

Under the authority thus granted, the Commissioner formulated a contract and specifications for such an agreement but it was found that the data upon which to base an intelligent judgment as to the fairness of the bids presented were lacking. Therefore the Board of Estimate and Apportionment appropriated $100,000 for the purpose of an exhaustive test. The details of the test were placed in charge of Mr. A. F. Gunther, a District Superintendent detailed as General Snow Inspector. Agreements were made with the owners of various types of machines by which they furnished a certain number of machines for an approximate test of 100 days at a per diem rate. Under this agreement the machines tested were: 10 American, 5 Ratigan 10 Connelly, 10 Sanitary, 13 Squegee, and 1 Studebaker.

All of these machines excepting the Squegee and Studebaker have the same general principle of operation. They consist of a barrel or tank of heavy boiler-steel construction, furnished with an inner chamber for the storage of compressed air. The water is introduced at the bottom at the rear of the machine and as the tank fills the air is compressed in the air chamber. When in operation the reverse of the operation gives the delivery of water under pressure furnished by the compressed air, and at a pressure dependent upon that obtained from the hydrant pressure. The water is delivered to the street at an angle which permits of its most efficient use in cleaning. This angle is adopted to the different kinds of pavement by adjustment of the nozzle.

The Squegee is a tank wagon which permits of the water being sprinkled on the pavement, and at the rear of the machine is a revolving spiral rubber scrubber which removes the filth and deposits it at the side of the machine in like manner as dirt is deposited by a machine broom.

The Studebaker machine has a barrel or tank like that of the ordinary flushing machine, but this tank is filled at the top without attempt at air compression. The machine is equipped with a gasoline engine which operates a rotary pump so that the water is delivered to the pavement under the required pressure.

Each machine required a pair of horses and a driver for its operation and therefore were comparable in labor and haulage costs.

Inasmuch as the Connelly machines were the first prepared to go to work it was found that they would be the only ones that could be moved through all of the districts, described further on. The test was made in the Borough of Manhattan alone as the city furnishes the water to that entire Borough and the Commissioner of Water Supply, Gas and Electricity felt that he could permit the use of the necessary water.

The Borough of Manhattan is divided for the purpose of Street Cleaning work into eleven districts, which may be roughly described as follows:

District No. 1 is the southern portion of the island south of Canal St. on the west side of Broadway and south of Chambers St. on the east of Broadway, and is a purely business district; No. 2 is between Chambers and Broome Sts., east of Broadway, and with No. 4, which lies between Broome and East 12th Sts., east of Broadway, forms the congested tenement district popularly known as the Ghetto; No. 3, from Canal St. to W. 22nd St. west of Broadway, contains the combined business and residence district popularly known as "Greenwich Village"; No. 5, from W. 22nd to 57th St. west of Sixth Ave. is a business and residence district; No. 6, from E. 12th St. to E. 40th St. east of Sixth Ave., and No. 8, which extends from E. 40th to East 72d St., east of Sixth Ave., is a combined business and residence district; No. 7, from West 57th to West 96th St., west of Central Park, is a residence district and with No. 9, north of West 96th St., and west of Lenox Ave., comprises a residence district of the better class; No. 10, from E. 72nd to E. 106th St., east of Central Park, is a residence district; No. 11, north of E. 106th St. and east of Lenox Ave., is a tenement district popularly known as "Little Italy."

In making the test the endeavor was to get figures of each machine in each district so as to cover the varying conditions. It was, however, found impossible to put all through the test in that manner; but, as already stated, it was found possible to put one type of machine through all and the others may be fairly compared by the results. In each district daily reports were made of the type of machine, number used in the gang, number of square yards of pavement cleaned, the amount of water used, and an approximate estimate of the percentages of pavements cleaned. The pavement cleaned was put under three heads; Asphalt, Granite and Wood. The data were summarized, with an estimate of cost to be submitted to the Finance Department. The summary given here (Table I.) contains the meat of that part of the information obtained which may be of benefit to street cleaners in other cities, but estimated costs have been omitted as they might prove misleading, being based wholly on local conditions. It is believed that with the information here given the data may be helpful elsewhere by using the costs and expenses proper to each locality.

TABLE I.—SUMMARY OF TESTS OF SIX MAKES OF FLUSHING AND WASHING MACHINES, MADE BY DEPARTMENT OF STREET CLEANING, NEW YORK CITY, IN 1909.

Type of machine.	No. of machines in gang.	Days tested.	Percentage of various pavements. Asphalt.	Granite.	Wood.	Sq. yds. cleaned per machine per day.	Gals. of water used per 1,000 sq. yds.
District No. 1.							
American	2	14	7	33	60	9,896	1,003
Ratigan	.	..	..	..	..	....	....
Connelly	2	47	9	53	38	12,611	903
Squegee	.	..	..	..	..	....	....
Sanitary	.	..	..	..	..	....	....
Studebaker	.	..	..	..	..	....	....
District No. 2.							
American	4	14					
	5	21	67	24	9	15,624	558
Ratigan	.	..	..	..	..	....	....
Connelly	2	11					
	4	8	67	20	13	16,846	481
Squegee	2	20	82	..	18	21,247	404
Sanitary	4	47	63	30	7	13,406	995
Studebaker	.	..	..	..	..	....	....
District No. 3.							
American	4	47	94	2	4	18,487	542
Ratigan	2	3					
	5	20	92	1	7	17,983	490
Connelly	2	2					
	3	3					
	4	9	89	1	10	26,476	452
Squegee	.	..	..	..	..	....	....
Sanitary	.	..	..	..	..	....	....
Studebaker	.	..	..	..	..	....	....
District No. 4.							
American	4	14	90	10	..	13,751	810
Ratigan	.	..	..	..	..	....	....
Connelly	4	21	99	1	..	21,657	566
Squegee	.	..	..	..	..	....	....
Sanitary	2	47	68	32	..	19,355	472
Studebaker	.	..	..	..	..	....	....
District No. 5.							
American	.	..	..	..	..	....	....
Ratigan	3	47	49	51	..	9,827	666
Connelly	2	14	62	38	..	28,980	328
Squegee	1	6					
	2	12	100	..	..	47,491	153
Sanitary	4	28	95	5	..	32,792	314
Studebaker	.	..	..	..	..	....	....
District No. 6.							
American	.	..	..	..	..	....	....
Ratigan	.	..	..	..	..	....	....
Connelly	2	16					
	4	7	77	23	..	26,689	463
Squegee	2	15	100	..	..	68,948	125
Sanitary	2	47	83	17	..	27,347	385
Studebaker	.	..	..	..	..	....	....
District No. 7.							
American	.	..	..	..	..	....	....
Ratigan	2	47	71	29	..	15,137	675
Connelly	2	38	89	11	..	*51,567	272
Squegee	2	16	100	..	..	75,161	91
Sanitary	2	13					
	4	15	88	12	..	28,234	371
Studebaker	.	..	..	..	..	....	....
District No. 8.							
American	2	47	89	11	..	18,679	499
Ratigan	.	..	..	..	..	....	....
Connelly	2	26	96	4	..	40,994	317
Squegee	.	..	..	..	..	....	....
Sanitary	.	..	..	..	..	....	....
Studebaker	1	41	43	57	..	*34,657	528
District No. 9.							
American	.	..	..	..	..	....	....
Ratigan	.	..	..	..	..	....	....
Connelly	2	24	89	10	1	38,572	273
Squegee	2	18	99	..	1	46,142	151
Sanitary	2	13	96	2	2	25,522	324
Studebaker	.	..	..	..	..	....	....
District No. 10.							
American	2	47	75	25	..	21,254	359
Ratigan	.	..	..	..	..	....	....
Connelly	2	25	75	25	..	25,862	387
Squegee	.	..	..	..	..	....	....
Sanitary	.	..	..	..	..	....	....
Studebaker	.	..	..	..	..	....	....
District No. 11.							
American	2	47	97	3	..	22,193	454
Ratigan	.	..	..	..	..	....	....
Connelly	2	20	100	..	..	42,651	187
	2	27	98	2	..	*40,222	240
Squegee	.	..	..	..	..	....	....
Sanitary	.	..	..	..	..	....	....
Studebaker	.	..	..	..	..	....	....

*Day work.

TABLE II.—SUMMARY OF DATA OBTAINED FROM NEW YORK STREET FLUSHING MACHINE TESTS, 1909.

Type of machine.	No. of machine days.	Percentage of various pavements. Asphalt.	Granite.	Wood	Sq. yds. cleaned—Total.	Sq. yds. cleaned—Av. per machine per day.	Gals. of water used—Total.	Gals. of water used—Ave. per 1,000 sq. yds.
American	778	74	16	10	14,279,105	18,353	7,740,450	542
Ratigan	341	71	27	2	4,831,603	14,169	2,961,250	613
Connelly	671	79	16	5	20,424,690	30,469	7,228,200	354
Squegee	144	100	..	..	7,484,766	51,977	1,108,330	148
Sanitary	598	85	13	2	13,651,179	22,828	6,517,100	477
Studebaker	41	43	57	..	142,992	34,658	750,750	528

TABLE III.—REARRANGEMENT OF STREET CLEANING DISTRICTS INTO STREET FLUSHING DISTRICTS, BOROUGH OF MANHATTAN, NEW YORK CITY.

(The Street Cleaning Districts Are Described Near the Beginning of This Article.)

Flushing District No. 1 formed from D. S. C. Districts Nos. 1 and 2.
Flushing District No. 2 formed from D. S. C. Districts Nos. 3 and 4.
Flushing District No. 3 formed from parts of D. S. C. Districts Nos. 5 and 6.
Flushing District No. 4 formed from parts of D. S. C. Districts Nos. 5, 6 and 8.
Flushing District No. 5 formed from D. S. S. Districts Nos. 7, 10 and part of 8.
Flushing District No. 6 formed from D. S. C. Districts 9 and 11.

TABLE IV.—COMPUTATIONS TO DETERMINE ESTIMATED AVERAGE YARDAGE AND WATER CONSUMPTION PER CONNELLY STREET FLUSHING MACHINE FOR WHOLE OF MANHATTAN BOROUGH, NEW YORK CITY.

Flushing district No.	Number of great squares to be cleaned. Daily.	Twice a week.	Weekly.	Reduced to daily work.	Average yardage and water consumption per machine. Per cent. of total daily work.	Actual in each district. Sq. yds.	Gals.	Computation for whole-city rate. Sq. yds.	Gals.
1	225	701	...	425	11	14,729	667	1,620.19	73.37
2	832	506	34	982	25	24,066	509	6,016.50	127.15
3	574	423	172	720	18	32,792	314	5,902.56	56.52
4	406	680	416	659	17	32,221	369	5,477.57	62.73
5	301	...	2,116	603	15	39,474	325	5,921.10	48.75
6	266	171	1,472	525	14	40,482	233	5,667.48	32.62
Total				3,914				30,605.40	401.14

The whole-city rates, 30,605.40 yds. and 401.14 gals., then show what each machine should do per day on a hypothetical district with weighted average conditions.

The Commissioner of Street Cleaning has under his jurisdiction the three boroughs of Manhattan, The Bronx and Brooklyn. In Richmond and Queens boroughs the street cleaning work is done under the direction of the Borough President.

Of the 24,200,000 sq. yds. of area under the jurisdiction of the Commissioner of Street Clean-

ing it is proposed to clean by flushing: 5,768,000 sq. yds. every other day, 6,030,000 sq. yds. twice per week and 5,797,000 sq. yds. once per week. The contract will be for five years, with the privilege on the part of the city of terminating it at any time after three years. The compensation will be at a price per great square (1000 sq. yds.) To avoid the carrying of the material removed from the street surface into the sewers, screens will be placed at the catch-basin inlets to retain the larger particles. The work of flushing is to be done at night and the removal of the materials is to be done the first thing the next morning, by the Department force.

For the purpose of contract the Borough of Manhattan is divided into six districts, the Borough of The Bronx is one district and the Borough of Brooklyn is eight districts.

Conclusions and Applications of the Tests.

From Tables I and II it appears that the Connelly machine, which was used in each district, gave an efficiency equal to if not better than the others; therefore for drawing conclusions from the test the results shown by this class of machine are here used.

Tables III. and IV. give the result of computations made to determine the average daily work and water consumption that may be expected from a single machine equal to the Connelly, working in Manhattan Borough. For flushing purposes, the present Department of Street Cleaning (D. S. C.) districts in Manhattan are to be regrouped into the six flushing districts, approximately as shown in Table III. The method then pursued to get the average yardage and meter consumption per machine may be seen by consulting Table III., from which it appears that on evening up varying local conditions in different sections one Connelly machine would clean 30,605 sq. yds. per day and that for this purpose 401 gals. of water per 1,000 sq. yds. of pavement would be required.

The Slow Sand Water Filters Under Construction at Reading, Pa.

By MANDES GOLDER.*

Two slow sand filter plants are now being constructed for the City of Reading, Pa. These are the Bernhart filters, with a capacity of 3,750,000 gals. per day and the Maiden Creek filters, with a capacity of 13,500,000 gals. per day. The above-named filter plants, when completed, together with the two smaller plants now in use, namely Egelman filters and Antietam filters, will purify about 99% of the water-supply of the city. The remainder of the supply is pure spring water.

The filters now being built differ from other slow sand filters of recent construction in the following: Shape of sections of end walls and dividing walls; method of forming floor joints; devices to prevent the leakage of unfiltered water along the walls and piers; design of effluent pipes.

The Water-Supply System of Reading.

The city of Reading obtains its water from five sources. The Antietam supply, now filtered, is a gravity supply, has a drainage area of 5.44 sq. mi. and a storage reservoir of 101,000,000 gals. capacity. Prior to being filtered the supply was wasted for several months during the summer of each year. This waste was made necessary because of a fishy taste and a disagreeable odor. The odor was caused by the presence in large numbers of the organism Anabaena. The supply is also contaminated by drainage from adjacent farms. The contamination occurs principally after heavy rainstorms and freshets. This supply furnished 25.09% of the water consumed in 1908.

The Egelman supply, now filtered, is a gravity supply, has a drainage area of 0.60 sq. mi., and storage reservoir capacity of 6,990,000 gals. This supply feeds the high-pressure service. Before filters were introduced this supply possessed a disagreeable taste and odor during the warmer months. These were caused, principally, by the presence of decayed vegetation. This source furnished 2.12% of the entire supply in 1908.

Bernhart supply, unfiltered, is a gravity supply, has a drainage area of 2.56 sq. mi. and storage reservoir capacity of 42,000,000 gals. Water from this source is contaminated by farm drainage. During 1908 17.26% of the city's supply was obtained from this source.

The Maiden Creek supply is pumped. It comes from a drainage area of 210 sq. mi. The capacity of the pumps is 30,000,000 gals. per day. The supply is contaminated principally, by farm and village drainage. This source furnished 54.51% of the city's supply during 1908.

The drainage areas of all the sources named contain numerous springs. Hampden Springs and Hampden Drift furnish absolutely pure spring water and 0.92% of the supply was obtained from this source in 1908.

Typhoid Fever Outbreaks.

Several outbreaks of typhoid fever occurred in Reading during the past years. In the fall of 1908, during one of these outbreaks the State Department of Health was called upon to assist in the prevention of secondary cases and in locating the probable source of infection. It was found that the consumers of the Maiden Creek supply were the principal sufferers. The State Department accordingly directed that the supply be treated with copper sulphate, a germicide. This was introduced into the water at the pump well at the rate of one part of copper sulphate to 1,200,000 parts of water. The quantity of copper sulphate introduced into the water was changed on Jan. 13, 1909, to 1 part in 3,600,000, and is still being used in this proportion.

The purification of the entire supply and especially the Antietam supply had been recom-

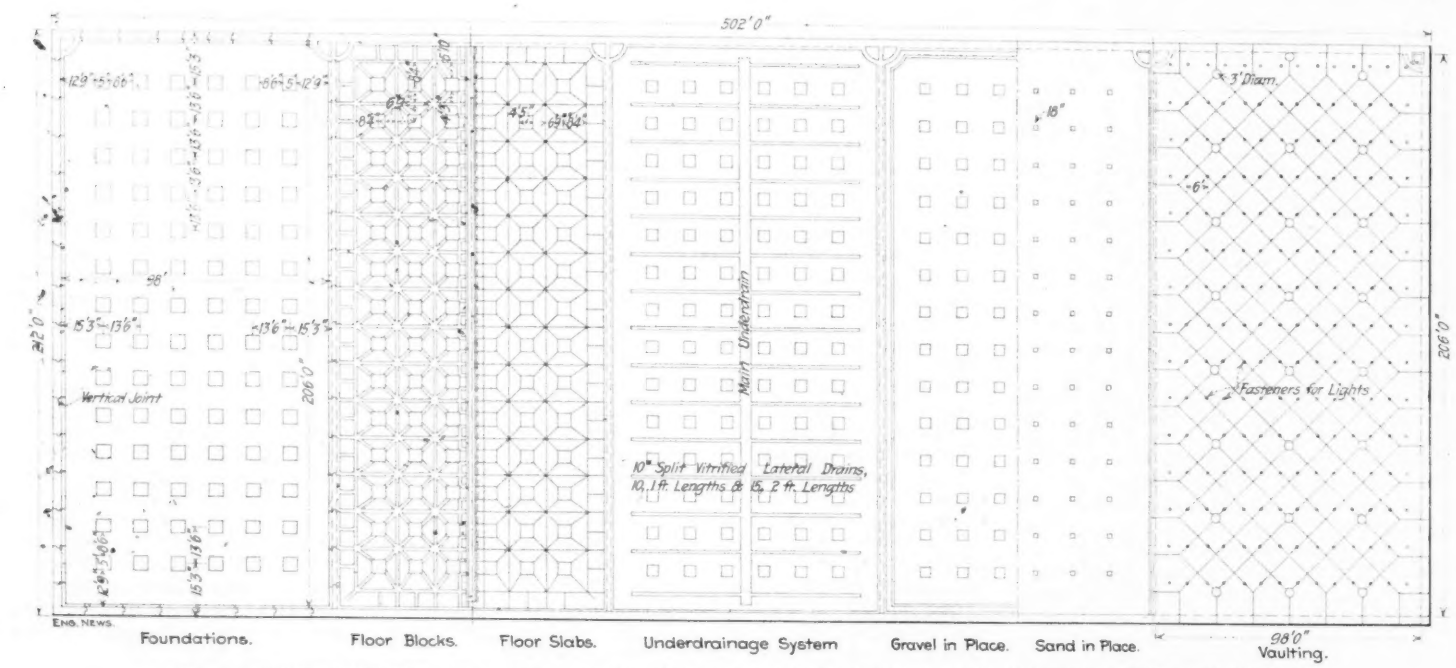


FIG. 1. MULTI-SECTIONAL PLAN OF FIVE OF THE MAIDEN CREEK SLOW SAND WATER FILTERS, READING, PA.

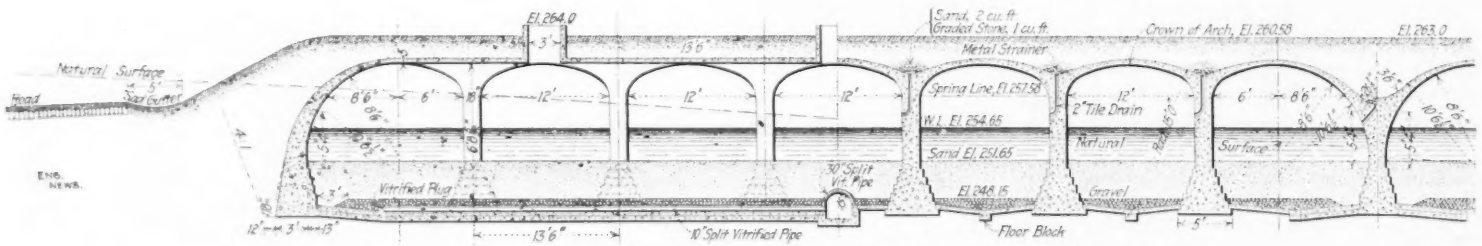


FIG. 2. PARTIAL LONGITUDINAL SECTION OF MAIDEN CREEK SLOW SAND FILTERS, READING, PA.

*Resident Engineer on Maiden Creek Filters, Reading Water-Works, Blandon, Pa.

mended to the city councils for many years before they allowed the water commission sufficient funds to construct purification works.

The Existing Filters and Their Efficiencies.

The Egelman Filters, put into service in 1903, consist of two open sand filters, 40x55 ft. in area, with a combined daily capacity of 500,000 gals. The water is aerated before entering the filters.

The Antietam Filters consist of three open sand filters, each 108x144 ft. in area, and with a total capacity of 5,250,000 gals. per day. These filters were put into service in 1905. As in the Egelman filters, the supply is aerated before entering the filters.

The average percentages of bacteria and turbidity removed by the two filter plants each year since their installation is given by the accompanying table.

AVERAGE YEARLY REMOVAL OF BACTERIA BY READING WATER FILTERS.

Fiscal year.	Per cent. of Bacteria removed.		Per cent of turbidity removed.	
	Egelman	Antietam.	Egelman	Antietam.
1903-1904.....	97.4	....	89.9	....
1904-1905.....	98.0	....	89.6	....
1905-1906.....	98.6	95.9	95.5	92.2
1906-1907.....	98.3	95.6	98.2	97.0
1907-1908.....	99.3	91.6	100.0	99.3
1908-1909.....	99.4	96.1	100.0	100.0

hard no provision has been made for softening it before filtration, the major object of the filters being to reduce the bacterial contents of the water.

New Filters.

The new filters are for the Bernhart and Maiden Creek supplies. The Bernhart filters are located about one thousand feet beyond the Bernhart dam. The location of the filter site was chosen: (1) to be approximately in line with the existing mains from the Bernhart reservoir to the distribution reservoir, so that the same mains could be used for the filtered water; (2) to keep the water in the filters at an elevation equal to that of the water in the reservoir minus the head lost in bringing the water, by gravity, to the site considered; (3) to avoid building on a fill. There are six units in all. Each unit is 138½ × 71 ft. inside and has a capacity of 750,000 gals. per day, or a total of 3,750,000 gals. with one bed out of commission for cleaning.

The Maiden Creek filters, ten in all, are situated at the junction of Maiden and Willow creeks. Each unit measures 98x206 ft. and has a capacity of 1,500,000 gals. per day, thus giving a total capacity of 13,500,000 gals. with one bed out of commission for cleaning. The filter sion joints every 10 ft. The connections between the conduit and the filter beds are 16-in. cast-iron pipes. The Bernhart and Maiden Creek filter plants are alike in general design, so it is necessary to describe only one of them.

Maiden Creek Filter Plant.

In the design of the plant three different phases were studied: (1) The design of the beds to accommodate the filtering materials. (2) the arrangement of the filtering materials, pipes and connections so as to give the desired rate and efficiency of filtration. (3) the arrangement, location, and dimensions of the units to give maximum economy. The general design finally adopted is shown by Figs. 1 and 2.

DESIGN OF BEDS.—In the design of the structural portions of the beds the following loads were to be carried and the following unit stresses allowed:

2 ft. of sand covering at 100 lbs. per cu. ft. Snow or other load which might come on filters, 50 lbs. per sq. ft.

Weight of concrete, 150 lbs. per cu. ft. Soil, bearing power, 2 tons per sq. ft. Allowable unit stress of concrete in tension in footings only, 30 lbs. per sq. in. Allowable unit stress of concrete in direct compression (1:2:4 mixture) 400 lbs. per sq. in. Allowable unit stress of concrete in shear, 50 lbs. per sq. in. Allowable unit stress of steel in tension, 16,000 lbs. per sq. in. Allowable unit stress of steel in shear, 10,000 lbs. per sq. in.

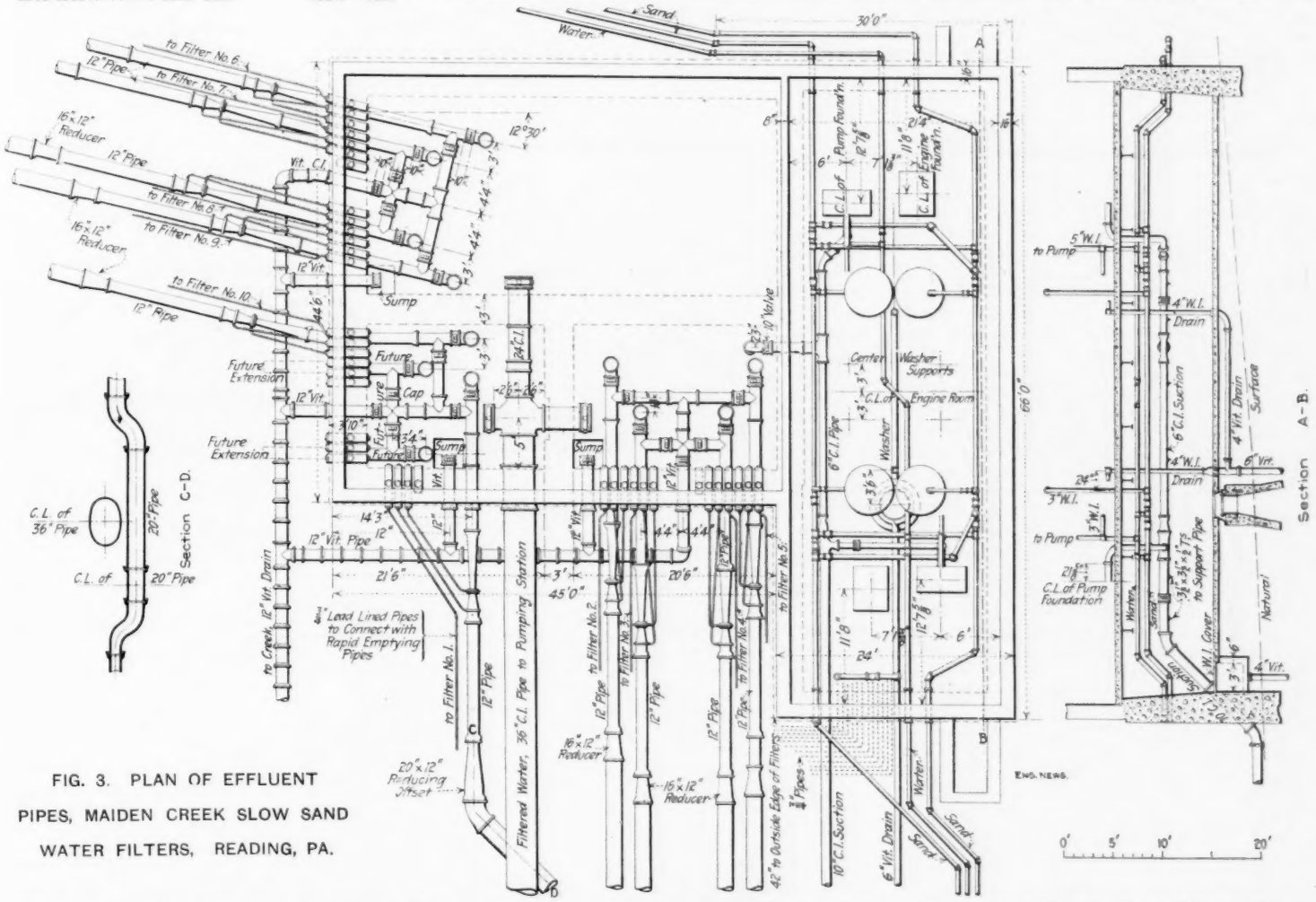


FIG. 3. PLAN OF EFFLUENT PIPES, MAIDEN CREEK SLOW SAND WATER FILTERS, READING, PA.

For the year 1908-9 (ending with March) 51 samples from each filter were analyzed (4 or 5 for each month except January, where only 3 were taken). The average bacterial contents of the water supplied to the Egelman filters was 719, while that of the filtered water was 4.2. The range of bacteria in the raw water was from an average of 2,967 in January, 1909, to 234 in March, 1908. For the Egelman filters the bacterial content for the year averaged 991; maximum, 4,143 in January, 1909; minimum, 185 in both April and January.

The high rate of efficiency of the Egelman filters was accountable for the adoption for the remaining supplies of the distinctive features possessed by the Egelman filters.

Though the water to be filtered is slightly

site was chosen: (1) to avoid building on fill; (2) to keep the elevation of the water in the filters equal to the elevation of the water in the pool above the dam minus the head lost in bringing the water by gravity to the site; (3) to allow the filtered water to flow by gravity to the pumping station; (4) to avoid damage to filters or interference with their operation by high water in the Creek.

In connection with these filters it was necessary to rebuild a small dam about eight thousand feet from the filter site and bring the water from the pool above said dam, by gravity directly to the filters. The conduit was given a capacity of 30,000,000 gals. a day, in order to provide for the distant future. It is of reinforced concrete, 5 ft. internal diameter, with lead expan-

The existing filters in the Reading water-supply are uncovered. Much inconvenience and expense are experienced in clearing the ice from these uncovered filters. The freezing of the sand in the filters during cleaning is also objectionable. Algae growths are encountered in these filters. These growths cause frequent cloggings of the filters during the warm months of the year. To overcome these objections a covered type was adopted in the new filters.

In designing the beds the depth of the filtering materials was assumed and to this depth was added what was considered sufficient head room for scraping the dirty sand. Having the total height different types of construction were considered.

VAULTING.—Several systems of covering were

designed, using both plain and reinforced concrete. The groined arch without reinforcement was found to be the most economical under the conditions of loading. Arches supported by lintel arches were found to be approximately as cheap as groined arches, but required more head room and were therefore not as economical. The not only on the thickness of the vaulting or slabs but also on the piers supporting same, the convenience in scraping the dirty sand and the amount of filtering surface in a given area. A clear span of 12 ft. was adopted.

The estimates of the different systems of plain and reinforced concrete show that the amount of construction because of the low tensile stesses developed in any part of the structure.

The contractor for the Maiden Creek filters erected a small power-carpenter shop where he built all forms during the winter months.

PIERS.—The piers were designed to take direct compression produced by the vertical components

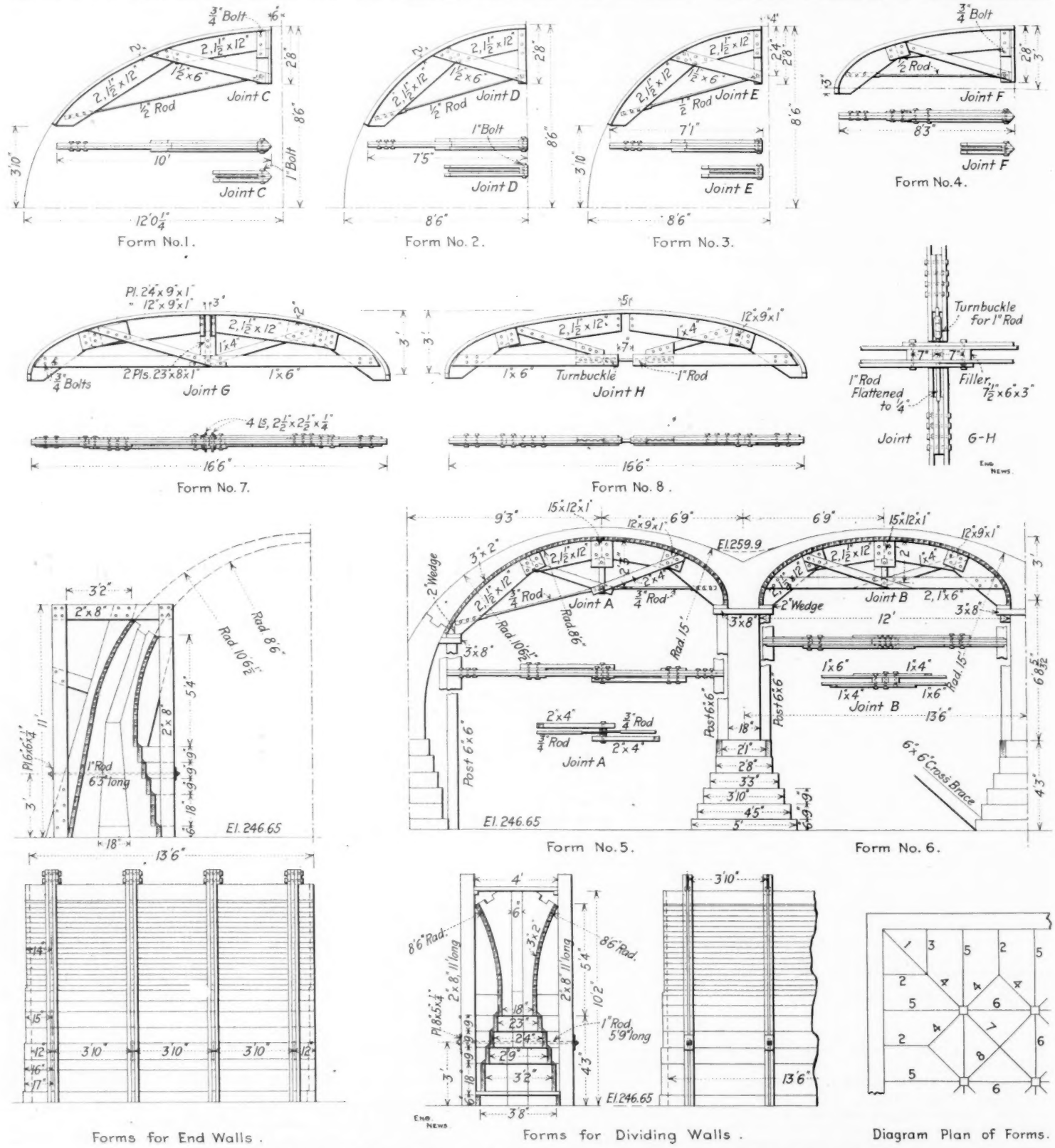


FIG. 4. FORMS USED FOR CONCRETE VAULTED ROOFS OF MAIDEN CREEK FILTERS, READING, PA.

following systems of reinforced concrete were designed: Girders supported by piers, with roof resting on girders; main girders supporting beams on which roof rested; steel girders supporting roof; reinforced slab supported by piers. In all of the above-mentioned systems different spans between piers and girders were used. The spans between piers and girders were dependent of concrete necessary for well-designed reinforced systems was approximately as much as that required for the groined-arch construction. The cost of the forms for the groined arches is a factor in favor of the use of reinforced-concrete construction but the cost of steel and placing of same more than offsets that cost. The plain concrete is used to advantage in this form of the thrusts of the arches. The horizontal components balance each other. Should there be any unbalanced thrust from unsymmetrical loading it would be taken care of by the shearing resistances of the piers. Provision was, however, made that during construction the forms for the vaulting shall be erected for an entire bed to prevent any great unbalanced thrust until

the entire bed is covered and concrete sufficiently set.

END WALLS AND DIVIDING WALLS.—Contrary of existing practice of end-wall construction for filters, curved sections were used, and so proportioned as to take the entire thrust from the roof. Rectangular and trapezoidal sections were tried but their areas were found to be far in excess of the curved sections. In some of the larger existing filters the end walls are proportioned inversely as the fill beyond the walls, thus placing dependence on the fill to help support the thrust. As the pressure from an embankment is unreliable it was decided to make the sections stable without relying upon the support of the embankment in any manner except by its weight in a vertical direction. In designing the end walls the effect of the pressure of the embankment was considered, as in a retaining wall, as was also the pressure of the

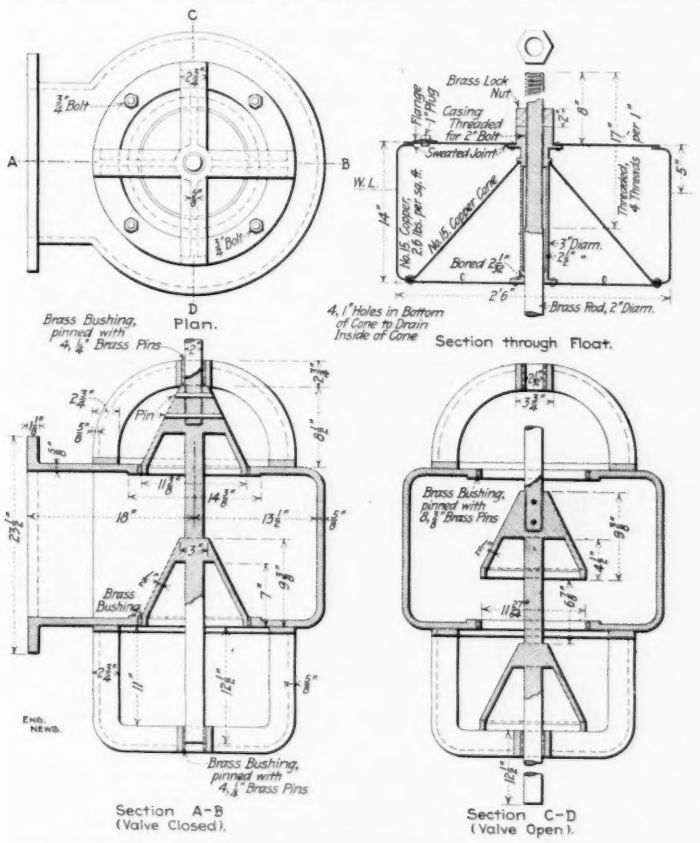


FIG. 5. 16-IN. BALANCED FLOAT VALVES FOR INLETS TO MAIDEN CREEK FILTERS, READING, PA.

sand and water inside the filters. The dividing walls are similar to the end walls. Each dividing wall is able to take the entire thrust from one filter without the support of the adjacent filter. This would prevent a total collapse should one unit fail for any unforseen reasons.

All walls and piers are stepped from the bottom of the filters to the top of the filter sand. The object of these offsets is to avoid a plane surface between the filter sand and the concrete. Should any unfiltered water pass between the concrete and the sand the steps would tend to stop the flow and prevent unfiltered water entering the underdrains. This stepping of the concrete is the distinctive feature of the Egelman filters and is probably the reason for the higher efficiency of these filters as compared with the Antietam filters, the walls of which are not stepped.

FLOOR BLOCKS.—Another departure from existing practices in filter construction is in the method of forming floor joints. The floor, as shown on the plan (Fig. 1) is divided into "floor slabs." These slabs are to be laid in alternate sections to avoid a perfect bond. Under the floor slabs "Floor Blocks" are first laid consisting of concrete blocks 12 ins. wide and 6 ins. deep. The floor blocks are coated with asphaltum.

The joints of the floor slabs are formed over the middle of the floor blocks. The object of the floor blocks is to prevent leakage through the floor slab joints. The asphaltum is to be applied as follows:

> After the top surface of the floor blocks and lowest projection of piers and walls are set and are perfectly dry, all dust shall be carefully brushed off, and on this dry, clean surface an asphaltum mixture, remaining soft at freezing temperature, shall be mopped on to a thickness of one-sixteenth of an inch, at a temperature of not less than 450° F.

SAND DASH.—Another device to prevent the leakage of unfiltered water along the walls and piers was planned as follows:

> After filling all voids with neat cement the surface of the inside walls and piers from the floor to the top of sand in filters, shall be wetted and immediately washed with a wash of thin, neat cement, followed immediately by dashing clean sand against the surface. The sand shall be thrown with enough force to make it adhere to the cement. After the cement has set the surface shall be brushed and any spots left uncovered shall be treated as above. The above treatment to continue until the entire surface is covered with a layer of sand.

Before deciding on this treatment several experiments were made which showed that the precautions named were necessary.

All walls holding water are to be finally washed with four washes of soap and alum solutions, applied alternately at boiling temperatures.

DESIGN OF FILTERING MATERIALS, PIPES AND CONNECTIONS.—The rate of filtration was assumed to be 3,000,000 gals. per acre per day. The depth of sand, gravel, and water to be used in the beds was decided upon from the results obtained with existing filters. The loss of head through sand and the gravel and the allowable loss of head through the lateral and the main underdrains were assumed to be no greater than that ordinarily found in well-constructed filters. After deciding upon the allowable loss of head for the lateral and the main underdrains and knowing the rate of flow the proper size and most efficient form of drains were computed. An effort was made to increase the size of the drains from the remotest part of the filter to the outlet pipe so as to keep the loss of head uniform from the most remote point of the bed to the outlet pipe. The change was too small to be considered practicable.

The sizes of pipes to carry the water from the filters to the filter house were dependent on the allowable loss of head. After deciding on the allowable loss, which in this case was 0.12 ft., the pipes from the different filters being of different lengths were so designed that the water from each line would reach the Venturi meter with the same loss of head. The diameters were figured by the following formula:

$$x\ f_1 + (l - x)\ f_2 = F = 0.12$$

in this case F = allowable loss

f_1 f_2 etc. = loss per lineal foot for a given flow and given diameter.

l = total distance between filter outlet and Venturi meter.

The advantages to be derived from this plan are: (1) For the given loss of head the sizes of the pipes from the nearer filters may be smaller thus saving in the cost of the pipes which in all cases is cast iron. (2) The entire loss of head through the filters and all other losses up to the Venturi meter are recorded as one total loss. The necessity of cleaning the filters is regulated by that total loss. If the loss of head between the beds and Venturi meters is the same for all filters, there can be one fixed allowable total loss before cleaning any filter, without making any calculations.

EFFLUENT PIPES IN FILTER HOUSE.—The effluent pipes entering the filter house are joined into three systems, as shown by Fig. 3. Pipes from four filters form a system. Before a bed is cleaned it is first drained. After cleaning it is necessary to back-fill that bed with filtered water. In the joined arrangement, as shown on plan, any filter in a system can be back-filled from any other filter in the same system by the proper regulation of the gates. These systems also avoid building separate compartments for the pipes of each bed. The number of drains is greatly reduced by these arrangements. The water from any filter may be wasted without interfering with the other filters.

METHOD OF CLEANING SAND.—The dirty sand after being scraped was to have been loaded into portable hoppers and carried by water pressure to the sand washers which were to have been located in the engine room. After the sand would have been washed it was to be carried through piping to another bed. This system necessitated the idleness of two beds, one being cleaned and one being filled, but obviated the necessity of sand storage bins, which bins are usually unsightly.

After the plans were completed the "Nichols Sand Separator" was put on the market and was adopted for these filters. This system requires only one bed to be idle at a time and thereby increases the capacity of the filters from 12,000,000 to 13,500,000 gals. per day. Provision was, however, made to carry out the first system should the "Separator" prove unsatisfactory.

Special valves were designed to regulate the flow of water into the filters (Fig. 5). A 36-in. cast-iron pipe carries the clear water from the filter house to the clear-water suction well. This well is located near the pumping station. Two 48-in. cast-iron pipes with reducing branches connect the pumps with the clear-water suction chamber.

Special connections were designed so that the pumps can draw either from the clear-water well or from the present unfiltered-water wells.

FORMS FOR CONCRETE.—In order to avoid any disputes with the successful bidder and insure stability of forms a set of forms was designed strong enough to stand the pressure of the wet concrete and the loads accompanying the placing of the same. The forms for the vaulting (Fig. 5) were made small enough to be able to remove them through the manholes.

ARRANGEMENT OF UNITS TO GIVE MAXIMUM ECONOMY.—The third step in the design consisted first in making a survey of both banks of the Maiden Creek from the pumping station to Glen Gery dam, a distance of about two miles. On this map a suitable location was found on the left bank of Maiden Creek below its junction with Willow Creek. Various dimensions and arrangements of the filters were then assumed and studied to ascertain the one which would give the most economical arrangement. The two sets of filters finally decided on make an angle in order to reduce excavation. In the calculations the elevation of the bottom of the filters governed, as no footings were to be built on fill. By building a retaining wall along the creek the excavation was considerably reduced and the allowable 1 on 2 slope on embankment was retained. The retaining wall connects with an existing retaining wall around the pumping station.

In connection with the filtration system all distributing reservoirs are being covered as advised by the State Department of Health.

All the construction work except Glen Gery dam is being done by Reading contractors, as follows: Reinforced-concrete conduit, Chiles & Witman; Maiden Creek filters, H. E. Ahrens Co.; Bernhart filters, Albrecht & Leader; covering distributing reservoirs, Fehr & O'Rourke. The contractor for Glen Gery dam is Carl R. Camp, of Montrose, Pa.

The entire filtration system and associated work was designed and is being carried out by Mr. Emil L. Nuebling, M. Am. Soc. C. E., Superintendent and Engineer of the Reading water works. The resident engineers on the various

jobs are, Conduit and dam, J. F. Witman; Maiden Creek filters, Mandes Golder; Bernhart filters, P. D. Kaufman; reservoirs, E. K. Cortright, Jun. Am. Soc. C. E.

It is expected that the filters and accessories will be completed and in use by June, 1911.

Test of a Helical Reduction Gear in Connection with a Steam Turbine on the 4,350-Ton Ship "Vespasian."

A paper on "The Application of the Marine Steam Turbine and Mechanical Gearing to Merchant Ships" was read by Mr. C. A. Parsons at the spring meeting of the British Institute of Naval Architects in London during the latter part of March.

The paper includes an account of a test of a steam turbine and helical speed-reducing gear on a typical slow-speed cargo vessel of 4,350 tons displacement. A gain in economy of 16% was shown over the results obtained in the same ship with reciprocating engines.

An abstract of Mr. Parson's description of the test was printed in a recent issue of the "Engineering Supplement" of the London "Times" as follows:

In the summer of last year the directors of the Turbinia Works Co. decided to test turbines mechanically geared to the screw shaft of an existing typical slow-speed vessel, and a cargo vessel named the "Vespasian" was purchased for the purpose. Her dimensions were: Length on load water line, 275 ft.; breadth molded, 38 ft. 9 ins.; depth molded, 21 ft. 2 ins.; mean loaded draft, 19 ft. 8 ins., and displacement, 4,350 tons. Before turbine engines with reduction gear were installed, the vessel was fitted with an ordinary triple-expansion surface-condensing engine, with cylinders 22¼ ins., 35 ins., and 59 ins., and a 42-in. stroke.

With a view to obtaining comparative figures between the turbine installation and the reciprocating engine, it was decided to run trials with the vessel with her reciprocating engine previous to its removal and the installing of the turbines and gearing. It was necessary, for the purpose of obtaining data under service conditions, that the vessel should be run at her loaded condition. Arrangements were consequently made with a local firm of shipbrokers to take a cargo of coal from the Tyne to Malta, and on June 26 of last year the Vespasian left the Tyne in a loaded condition with a special recording staff on board, and on the voyage careful measurements of coal and water consumption were made. On the completion of the voyage the vessel returned to the Turbinia Works, where her reciprocating engine was taken out, the engine seats remodeled, and preparations made for the reception of the turbines and gearing.

The only alteration made to the vessel was in the type of propelling engines; the boilers, propeller, shafting, and thrust blocks remained the same as for the reciprocating engine. The propelling machinery consisted of two turbines in "series"—viz., one high pressure and one low pressure, the high-pressure turbine being placed on the starboard side of the vessel and the low-pressure on the port side. At the after end of each of the turbines a driving pinion was connected, with a flexible coupling between the pinion shaft and the turbine, the pinion on each side of the vessel being geared into a wheel, which was coupled to the propeller shaft. A reversing turbine was incorporated in the exhaust casing of the low-pressure turbine. The high-pressure turbine was 3 ft. in maximum diameter by 13 ft. in length over all, the low-pressure one being 3 ft. 10 ins. in diameter by 12 ft. 6 ins. in length. The turbines were similar in design to a land turbine, being balanced for steam thrust only, the propeller thrust being taken up by the ordinary thrust-block of the horse-shoe type, which was fitted aft of the gear wheel.

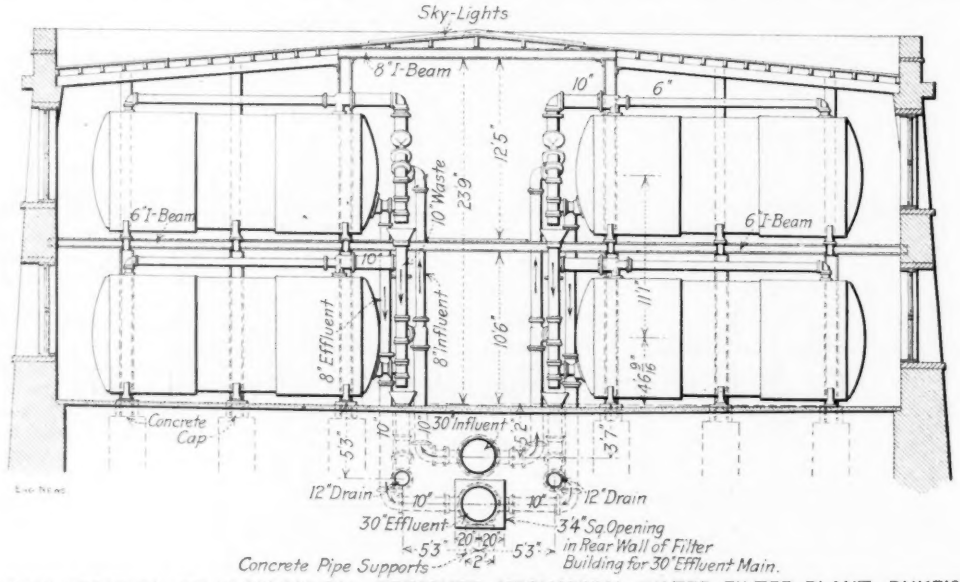
The gear wheel was of cast-iron, with two forged steel rims shrunk on. The pitch diameter of the wheel was 8 ft. 3½ ins., with 398 teeth—double helical—giving a circular pitch of .7854-in. The total width of face of wheel was 24 ins.; inclination of teeth 20° to the axis. The pinion shafts were of chrome nickel steel, 5 ins. diameter pitch circle, with 20 teeth. The ratio of gear was 19.9 to 1.

At the end of last February, the vessel was loaded to the same conditions of draft and displacement as those which applied to the trials already referred to, and on March 11 a run was made off the Tyne at varying revolutions. The author showed the results which had been obtained from these series of tests in various tables and curves. One of the curves relating to water consumption showed that with the reciprocating engines the hourly consumption for all purposes, at 56 r. p. m. of the propeller, was approximately 9,700 lbs., as against 9,400 lbs. with the turbine gear. At 60 r. p. m. the figures were about 11,700 lbs. and 10,700 lbs., respectively, and at 70 r. p. m. they were 17,500 lbs. and 14,700 lbs.

A 10,000,000-Gal. Pressure Mechanical Water-Filtration Plant at Duke's Farm, Somerville, N. J.

By GEORGE F. HODKINSON.*

The country estate of Mr. J. B. Duke, comprising some 1,700 acres of land located near the town of Somerville, N. J., and bounded on one side by the Raritan River, is known as "Duke's Farm." This is somewhat of a misnomer, for instead of being a place such as its name would suggest, it is a country seat of superlative beauty presenting an endless panorama of park-like roads and walks winding through groves and between hedges. Surprises greet the visitor at every turn. Classical statuary, graceful fountains and old-world gardens delight the eye. A striking feature, and perhaps one which will impress the beholder above all else, is the marvelous ingenuity displayed in the arrangement and working out of lakes, cascades and rustic bridges, all in perfect harmony with the surroundings, consummate art and skill transforming these acres of New Jersey woodland into a veritable Versailles. Like many of the show places of England, the enjoyment of the beauties of Duke's Farm is not denied the public, and a day spent in this modern Eden is not likely to be soon forgotten.



CROSS-SECTION OF 10,000,000-GAL. PRESSURE MECHANICAL WATER FILTER PLANT, DUKE'S FARM, SOMERVILLE, N. J.

To supply an abundance of water for the lakes, fountains, waterfalls, and for sprinkling and the general uses of so large a place, is not a small undertaking. The source of supply is the Raritan River, for the greater part of the year a turbid stream whose waters would hardly be in keeping with the generally artistic character of the fountains, lakes and cascades through and over which it is required to flow. To render this water sparkling and clear, regardless of the turbidity of the river, there has been installed a filtration plant sufficiently large to supply a town of 100,000 inhabitants.

Before entering upon a description of the filtration plant it may be mentioned, as a matter of general interest, that at the works of the Raritan & Somerville Water Co., within a stone's throw of the new pumping station and filter plant for supplying water to Duke's Farm, there was installed, in about the year 1885, the first mechanical filters ever erected for purifying a city or town water-supply, these filters marking a new era in the filtration of water on a large scale and the beginning of the development of the American or rapid system of water purification.

The new Duke pumping station is an ornamental structure of red brick about 75 × 250 ft. in plan, divided into three separate rooms. The center room is occupied by two 10,000,000-gal. horizontal cross-compound crank and flywheel pattern Allis-Chalmers pumping engines; in the east end of the building there are two Harrisburg water-tube boilers, while the west end of the structure constitutes the filter house.

The filter plant consists of 20 horizontal steel tank pressure filters, each 8 ft. in diameter by 20 ft. in length, with an aggregate minimum capacity of 10,000,000 gals. per day of 24 hours. The arrangement of the filters in two tiers, with ten units at ground level and ten immediately above, is unique, and one never before attempted, a structural detail necessitated by limited area. (See cross-section). The ten filters at ground level are placed in two rows with five filters on either side of a centrally-located walk or operating floor, beneath which the main influent, effluent and waste pipes are concealed. The upper ten filters, supported by structural steel, are placed directly above those at ground level.

All operating valves are immediately in front of each filter and conveniently located for performing the several operations of filtering, washing and filtering to waste, each valve-wheel being fitted with a brass plate to designate its function. The filters and all piping are designed for a working pressure of 130 lbs. per sq. in. The main influent and effluent pipes have a diameter of 30 ins.

On the interior of each filter is located a supply and wash trough, running the full length of the shell, perforated on either side, and closed at both ends, this trough serving the two-fold purpose of equally distributing the inflowing water to prevent its impinging upon the surface of the sand-bed and interfering with its filtering functions, and uniformly collecting wash water throughout the entire length of the apparatus to avoid the formation of channels during the washing process and the flow of wash water through contracted areas of the bed of filtering material which might offer the course of least resistance and otherwise promote such conditions. Water is supplied to and taken away from this trough by pipe connections at either end of the filter, instead of a single connection close to the front head, as is often the case.

The filter tanks are liberally provided with hand-holes located to minimize trouble in adding or removing filtering material. The waste wash water, and the first filtered water, is discharged into open cast-iron funnels, an arrangement which permits the filter attendant to detect waste of sand with the wash water, to determine when the filter-bed has been sufficiently cleansed and also when the first filtered water is running clear and the filter ready to again be turned into service. Each filter is equipped with a test bibb from which samples of filtered and unfiltered water may be drawn for analysis

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or inspection or for locating any filter which may not be delivering water of proper quality.

The water manifold or strainer pipes in these filters are cast-iron, of the Universal make, while the strainers or sand valves are heavy brass, of the Hodkinson pattern, distributed over the bottom of the filters, 6 ins. c. to c. The space below the water manifolds is filled with concrete and surfaced with cement mortar to make a solid floor with only the strainer heads exposed above its surface. Over the strainers or sand valves is spread an 8-in. layer of properly graded silicate gravel, supporting a 4-ft. layer of silicate sand with an effective size of about .35 mm. The filters are piped so that they may be cleansed with either filtered or unfiltered water, the entire bed being washed at one operation.

As the alkalinity of the river water is at times too low to decompose the requisite quantity of coagulant (sulphate of alumina) to effect the desired degree of purification, provision is made for applying artificial alkalinity in the form of soda-ash solution. Space between the walls or piers supporting the filters is utilized to form two rectangular solution tanks, one for sulphate of alumina and the other for soda ash, in which are prepared solutions of standard density. These solutions are added to the applied water, prior to its delivery to the filters, by two synchronous, variable stroke, chemical feed pumps, of improved design, hydraulically actuated by the steam pumps supplying water to the filters. One chemical pump feeds soda ash and the other sulphate of alumina. The chemical pumps are so piped that either or both may be operated by either of the steam pumps. As the steam pumps take their suction from a large intake well, the soda solution is delivered immediately beneath the suction pipes, while the sulphate of alumina is discharged into the 30-in. main leading to the filters and from which a branch is taken to lead the treated water to the old filter plant. The chemical pumps have a motor end and a chemical end, the motor ends being of brass and fitted with cup-leather plungers, while the chemical ends are of brass, lead lined, and fitted with hard-rubber plungers. The top and bottom heads of the motor end of the chemical pumps are connected, respectively, with the front and rear head of the water end of the steam pumps by 1-in. pipes; each revolution of the steam pump, therefore, compels a stroke of the chemical pump.

Tables are prepared to show the displacement of the chemical pumps for various lengths of stroke, also the cubic inches of chemical solutions to be delivered, per minute, to apply a given quantity of the chemicals in grains per gallon. Since the displacement, per revolution, of both the steam pump and the chemical pump is known, and since the chemical solutions are prepared of uniform density, it is only necessary to adjust the stroke of the chemical pump to apply any required volume of the chemical solutions to give the desired proportion in grains per gallon. The chemical pump once adjusted, the application of the chemicals to the applied water is constantly proportionate to the volume of water delivered to and through the filters until the pump is next adjusted for applying more or less chemical as the condition of the water under treatment might require.

The filter plant and chemical feed apparatus was designed by Geo. F. Hodkinson and installed by the American Water Softener Co., of Philadelphia, Pa. The construction of the new pumping station and water-works system has been carried on under the able direction of Mr. D. J. Smith, Supt. of Duke's Farm; the works will be operated by Mr. David Loree, Engineer.

THE SWISS FEDERAL RAILWAYS have secured an agreement with the Oerlikon Works, of Oerlikon, near Zurich, Switzerland, by which the former secure the latter's right to develop power on the River Etzel. By this agreement the Federal Railways control the possible development of 60,000 HP. in addition to other rights controlled, which are reported to have a possible total of 250,000, peak load. This is about half that required should the railways determine that all their lines are to be electrically operated eventually.

The Influence of Forests on Climate, Floods and Erosion.*

By GEORGE F. SWAIN,† M. Am. Soc. C. E.

Preliminary Note.

It is stated on the title page of Prof. Moore's paper, that the paper was prepared at the request of the Chairman of the Committee on Agriculture, and printed by direction of the Committee. It is published at the precise time when the Weeks' Bill is under consideration by the Committee and it is therefore fair to presume that its preparation and publication were undertaken for the purpose of affecting the minds of the Committee and of the public with reference to this bill. The Weeks' Bill authorizes the purchase of forest reserves by the Government in such localities as may be found desirable with reference to the maintenance of navigable streams, and while the bill does not limit the location of such reserves to any particular state, it is presumed to apply particularly to the Eastern states and expected that it will result in the acquirement of forest reserves in the Appalachian and White Mountains. It is the outcome of earlier bills in which these locations were specifically named.

Although there are many good reasons why the forests of the country should be protected, the only legal justification for the acquirement by the Government of forest reserves by purchase, rests upon the jurisdiction of the Government over navigable streams, and therefore depends upon the relation between the preservation of forests and the maintenance of the navigability of streams.

These facts should be borne in mind in reading Prof. Moore's paper. As Prof. Moore had been requested by the Committee on Agriculture to assist them in the consideration of this subject, any arguments in his paper must be read remembering that he knew that he was contributing to the discussion of a subject in which congressional action depended alone upon the relation of forests to the navigability of streams.

[Here the author gives an interesting discussion of the inductive and deductive methods of scientific investigation.—Ed.]

Effect of Forests on Rainfall.

Fourteen pages out of 36 in Prof. Moore's paper are devoted to a discussion of the relation between forests and rainfall.

This relation is of no consequence so far as concerns the Weeks' Bill, or the claims made by those who believe that the Government should acquire forest reserves. No one has insisted, so far as I know, that forests have any considerable effect upon rainfall.

[Prof. Swain here discusses forests and rainfall at considerable length, bringing forward numerous arguments designed to show that Prof. Moore's reasoning on this subject is erroneous and inconclusive.—Ed.]

All this, however, is of little consequence as compared with the larger question, and the main question, as to the effect of forests upon floods and the navigability of streams. It must also be remembered that those who are in favor of the Weeks' Bill do not argue, as Prof. Moore would seem to make it appear, that the forests must be preserved on areas suitable for cultivation and needed for cultivation. "The pleading of the poor man's children for bread and meat," referred to by Prof. Moore, is a sentimental obscuring of the question. What is claimed is that on the steep slopes and mountain sides which are not suited for agriculture, the forests should be preserved, not only as a source of lumber supply but as a protection against the fires which are most apt to start on the cleared lands, and as a protection to navigation by preventing erosion and the silting up of streams, and also as a source of beauty and health; but the legal justification must, as already stated, rest solely on the effect upon navigation.

Effect of Forests upon Floods.

In studying the effect of forests upon floods by the statistical or inductive method, we meet with even greater difficulties than in studying the effect upon rainfall. One of the most important of these difficulties arises from the fact that we can vary only one element at a time. Not only is the rainfall different in different years on a given area, but the proportion of that rainfall which flows off in the streams, even if the rainfall is precisely the same, may vary in different years by 100%. Equal variation occurs in the manner in which this water flows off; a large amount may flow off without causing a flood, or a smaller amount may flow off causing a great flood. Now, in order to demonstrate by induction the effect of forests on floods, it would be necessary to have the same area under identical conditions except that at one time it should be forested and at another time it should be deforested; this condition is manifestly impossible of attainment; it never has been attained and it never will be. In the published comparisons which are found in various papers dealing with the subject, the conditions are never the same.

Statistical reasoning is unsatisfactory in this case, as it is in connection with the rainfall, and we must therefore resort to deductive reasoning based on simple fundamental principles; and here again there are two principles which every observing man knows to be true and which no amount of specious reasoning like that of Prof. Moore will suffice to counteract.

These are, first, that the forest retards the discharge of water from the surface of the ground. The forest causes a million dams, which obstruct the surface water and cause it to trickle along slowly; it also forms a bed of humus which is able to absorb this water; beneath which is a porous ground which can carry it still deeper. When a sudden downpour comes, not only do the forest trees intercept a portion of rain on their leaves and branches and allow it to trickle gradually down the trunk or drip to the ground, but the water, when it reaches the ground, is obstructed and has time to sink in, and finds something to sink into. On the open ground, on the contrary, on steep slopes (and it is only these that we refer to) a sudden downpour causes the water to be discharged quickly over the surface into the streams. If the forest, then, as every reasonable man knows is the case, retards the surface runoff, it must, on the whole, diminish the violence of freshets.

The second fact of importance is that the forest retards the melting of the snow; everybody familiar with the country knows that in the forest the snow lasts considerably longer than it does in the open, although there may be isolated drifts in the open where certain beds of snow may lie longer than the snow in the forest. On the whole, and speaking generally, forests retard the melting of the snow, and therefore every reasonable man will conclude that they must, on the whole, by causing the snows to be discharged in a longer time into the streams, reduce, on the average, the floods. Moreover, by facilitating the percolation into the ground and the subsequent slow giving out of the percolated water by springs and seepage, the forests must, on the whole, maintain a higher low-water flow in the streams.

Prof. Moore's arguments on this point—if they may be called arguments—are in part faulty and in part based on a misconception of the question, as will now be shown.

In the first place, the sum and substance of his claim is that forests do not decrease the *extreme* floods or increase the *extreme* low water-flow. This has long been admitted by competent hydrologists. It is even possible to conceive of circumstances under which the presence of a forest might increase the flood which, if the forest were not there, would come from a given area. But the navigability of streams, the formation of bars, the silting up of channels, do not depend upon extreme conditions. Three or four moderate floods may do as much damage to a navigable river as one extreme flood, and may bring down more sediment to be deposited in the river bed. Prof. Moore's authorities in this particular discussion are Prof. Cleveland Abbe and two French engineers, M. Belgrand and M. Vallés, both of whom wrote their original discussions on this subject over 50 years ago. To his quotation from Prof. Abbe we need pay little attention, as it has reference to level ground, whereas we are discussing the effect of forests on steep slopes. Ploughed and cultivated land is very likely quite as porous and quite as able to absorb rain-water as forest ground, as Prof. Abbe says. It is not quite easy to understand, however, how he can make out that "under a forest less rain actually enters the humus," and yet goes on to say "that the amount of water that is eventually given up from the forest humus varies but little from that given up in the course of time by the unforested cultivated soil." Less rain enters the humus but essentially the same is given up from it.

With reference to the French writers, Belgrand and Vallés give exactly the same arguments that are advanced by Prof. Moore, and by Colonel Chittenden in his recent paper to which the present author published a reply a few months ago. A sample of M. Vallés' reasoning may be quoted to show the kind of logic which appeals to his mind. He says that forest ground is less porous than bare ground because if you should ask a laborer in which he would prefer to dig a hole he will select the latter. He might as well argue that an acre covered to a depth of 10 ft. with a mattress of barbed wire was less porous than hard-pan for the same reason. As a matter of fact, both of these authors entirely agree with the position taken by the present writer and by those who urge the passage of the Weeks Bill, that forests should be maintained on steep slopes which are unsuitable for cultivation. Belgrand says, for instance:

> The operation of reforesting is thus excellent when practically possible, although it seems demonstrated that the deforestation of the basin of the Seine cannot be considered one of the causes which have contributed to increase or to decrease the height and the number of floods. *But the forests diminish very notably*

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*Extracts from a Discussion of a Report by Prof. Willis L. Moore, Chief of the U. S. Weather Bureau, entitled "The Influence of Forests on Climate and on Floods," presented to the Committee on Agriculture, U. S. House of Representatives, early in 1910. A condensation of Prof. Moore's report was printed in Engineering News of March 3, 1910. The extracts from Prof. Swain's paper are taken from an advance copy of a contribution to "American Forestry."

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the volume of earthy matter transported by the streams, because they prevent the erosion of the earth, and, it must be recognized that the impoverishment of the earth is much more to be deplored than the disasters caused by floods.

Mr. Vallés says:

If the demand is limited to the reforestation of the summits and uncultivated slopes, we wish well of it, but less from the point of view of diminishing the quantity of water discharged than from that of preventing the erosion of the earth, particularly if a study is made of reforestation in itself, which shall indicate to us, first, in what circumstances it can be realized, and in the second place, under what conditions it will be useful at the same time to private interests, and will be for the general good. If it is thus that we are to understand the advocates of this system, we do not hesitate to join with them; but if their demands are more extended, if they wish us to re-establish on ancient foundations a condition of things which has been usefully modified, if they desire that we should prefer the Druidical forests to our modern farms, the trees to the corn, the acorns to the grain, we say to them for the third time: reforestation will not do.

Bearing in mind that Prof. Moore's argument was written as a contribution to the discussion involved in the Weeks Bill, it would be interesting to inquire why he did not quote these two passages, if he knew of them. If he did not know of them he should not discuss the subject and give the erroneous impression that these authors denied the necessity of preserving the mountain forests.

Equally misleading is Prof. Moore's quotation from the Austrian engineer, Mr. Ernest Lauda (page 19) and the conclusions of the Tenth International Congress of Navigation held at Milan in 1905. Prof. Moore says that Mr. Lauda's conclusions are "that progressive deforestation of the country has had no effect in increasing floods nor in augmenting their height." Let us now read Mr. Lauda's conclusions as presented at the Congress in Milan. He says:*

If now the final judgment on the subject of the influence of forests on the regimen of streams be unfavorable to the forest to this extent, that there are denied to it certain of the properties attributed to it generally, it does not follow from this that it is necessary to oppose the re-wooding of arid surfaces, the replanting of the basins of streams or the maintenance of plantations of trees. The general utility of the forest is so well settled, the extraordinary appreciation in which it is held, *as a means of protecting the soil against landslides*, is so firmly established, its great advantageousness, especially for the spring district, in holding back earth thrusts and *reducing the amount of sediment carried by rivers* so important, *that these reasons alone justify fully the greatest possible promotion of forest culture.*

Any fair discussion would have included this reference.

Prof. Moore, referring to this Congress further says: "The writers heartily favor the protection of the forests and their cultivation," but "they were unanimous in the opinion that forests exercise little influence upon either the high water or the low water of rivers."

Let us now quote from Cipolletti's review of the conclusions of this Congress. He says:*

The other part of the question, concerning the influence of forests upon surface waters, is perhaps the most important of all and to all; and it is, no doubt, the one upon which our authors' opinions differ most. One may state that they all recognize, or at least none denies, the beneficial influence of forests upon the regimen of a river in its state of low-water flow, high-water flow, and ordinary floods; but many of the writers, we may say the majority of them, deny that forests have any power not only of preventing, but even of mitigating to any appreciable extent the more serious and more damaging floods, which occur in every country at certain periods.

The low-water flow—as is commonly known—depends almost exclusively on springs; and having once admitted the fact, that a covering of trees exerts a beneficial influence upon the flow of springs, we may at once draw from it the legitimate conclusion, that the regimen of low-water flow of a river is favorably affected by the existence of forests in its basin; except, be it well understood, the cases already alluded to, of an extremely permeable soil or of lands which can be cultivated without the loss of the humus covering, cases in which, as has already been stated, it is possible that deforestation may help the absorption of the water into subsoil and thereby the increase in volume of the low-water flow in the general recipients, the rivers.

But with regard to the regimen of high-water flow and ordinary floods, there is no material difference of opinion. In such localities the waters running off the surface unite with the springs in providing the supply of water for a river. Thus, all the writers agree that forests exert a moderating influence on the run-off of surface waters, owing to a large proportion of the water being retained by the leaves and other parts of the plants, also on account of a quantity of it being absorbed by the layers of dead leaves, moss and humus which form the top covering of the forest ground, and partly also owing to the obstruction which roots above ground form to the rapid flow-off of the surface water, by forcing it to remain stagnant in a thin sheet, instead of accumulating in a mass and running off quickly in the shape of brooks, which is what happens where the surface water finds little obstruction and is apt to produce erosion. To this may be added, in the case of cold climates, the additional advantage that the snow lies longer in the forest and melts here more slowly than in the open country. To conclude, forests act as real regulators, obliging the rain water to flow much more slowly to the bottom of the valley, than it would do otherwise, and by this means ensuring a more uniform and continuous flow in the lower reaches of rivers.

But, as already stated, opinions differ widely the moment we approach the subject of phenomena which are apt to produce heavy and extraordinary floods. Some of the authors (Messrs. Ponti, Keller and Wolfschurtz) assert with insistence, that heavy floods are due entirely to climacteric causes and that, consequently, the influence of forests is nil, or at any rate so small, that it can be neglected altogether. The reasoning by which they arrive at this conclusion is as follows: These great and extraordinary floods, they assert, only occur after downpours lasting several days; hence, under similar circumstances we must take it for granted that the leaves and all other parts of the plants have already soaked up the maximum quantity of water they are able to retain, that the upper layer of the soil is completely saturated and that the surface waters have already reached the bottom of the valley, when it is still raining in the more elevated and more distant parts of the catchment area. Under these circumstances, they maintain, the volume of water which comes down as rain is equal to the volume of water which flows to the bottom of the valley in the same time; in other words, the moderating influence of forests—like that of lakes and every other agency of this kind—tends to fall off with increasing length of time, while the phenomena lasts until finally a point is reached, when the efficiency becomes nil. Such is the fundamental argument of all these writers and it does not appear to us that anybody has given them as yet a pertinent reply. Although I am only a reporter, I may be allowed to interpose in the question, because it does not appear to me that things happen exactly as they might appear. In the first place, I may remark that in order to arrive at such a necessary state of equilibrium, it is not enough, that the phenomenon should last for a sufficiently long period of time, but it is also necessary that the intensity of the phenomenon should also remain uniform during the whole period. Everybody will see, how during the same period partial compensation will take place, the outcome of which will be a tendency towards the average value of intensity, with an elimination of the greatest crises, which in itself is already a no mean advantage; but there is still more than this. By admitting that in consequence of the prolongation of the rain, a moment is at last reached when there is as much water coming down into the valley as there is coming down higher up in the catchment area in the form of rain, it still has to be proved—and as a rule this does not happen—that this state of equilibrium coincides exactly with the moment of the greatest intensity. In every instance in which I had to study phenomena of this kind in respect of lakes and floodings of valleys, I found that this period of equilibrium was reached invariably when the rain was abating, that is, when a falling off had already taken place in the intensity of the phenomena; in other words, that the phenomenon had reached its maximum degree of intensity before the moderating power had become exhausted, the latter having thus already made its beneficial influence felt at the most critical period.

If we next proceed to studying the question by the light of recorded facts, doubts arise and difficulties are met with, which are perhaps not less serious.

The advocates of the two opposite views have endeavored, by means of minute and most laborious researches to get an insight into the past and to see whether it was possible or not to discover any difference in the regime of great rivers for the past century, a period from which, generally, date the deforestation carried out on a large scale in Europe; but they always found themselves face to face with very serious difficulties, to which I will only allude briefly.

All records which refer to great floods in past centuries are always surrounded by so many uncertainties and doubts, that it is most difficult—not to say impossible—to draw any certain and undisputable conclusions therefrom. We have a striking example of this in the Tiber—a river after which the Nile is certainly the most historical of all—in the case of which it has been so far impossible to ascertain if its floods have undergone any change in the course of centuries.

Can the destruction of forests bring about a great deterioration and even the total loss of the layer of cultivated soil of cultivated lands, of those which are next to them or lying beneath them, and, even further off, of the level portions of large valleys? Can it also cause land-slips, land-slides, and avalanches?

Upon this point it will be very much more easy for me to arrive at a conclusion *because the authors of the papers, without distinction, and all technical experts generally admit that the deforestation of sloping lands, especially if it is followed by a breaking up and cultivation of the soil, will cause the damages and injuries enumerated at the head of this chapter.*

Otherwise, it is easy to understand, and we are all daily witnesses of it, that when land with a sufficiently steep slope is deprived of the protection which roots of trees offer against erosion, and still worse, when the soil is subsequently broken up with plough or spade, the water, being able to flow off more quickly and to collect on a surface which offers but little resistance, can very easily remove and carry away with it to the bottom the earthy materials which form the cover, and leave the land denuded and barren. One can also easily understand that brooks, formed in this manner, can produce similar effects as regards laying bare the top of the slopes and carrying the material to the bottom of the incline, a place where the ground is better situated; and that the deep gullies, which similar, small but impetuous, torrents scour upon the slopes of mountains and hills, can in their turn also cause the land-slides and falls, especially if the underlying rock is of a soft and friable nature, and is, therefore, liable to being washed away easily. It is equally evident that on a slope, which is denuded of trees, avalanches are more likely to occur and will be more destructive than on a forest-clad hill, no matter how steep the incline may be. The influence of deforestation on valleys, even when situated at a distance, though less apparent and obvious, is nevertheless equally certain and disastrous.

. . . . . .

Prof. Moore says "army and civilian engineers and meteorologists generally believe that the broken, cultivated, permeable soil is equally as good a conserver of the rainfall as the forest area itself." Here again Prof. Moore obscures the point of this subject by talking about cultivated areas, although he knows perfectly well that his paper would be used as an argument against the preservation of forests on the steep slopes not suitable for cultivation. I protest against such misrepresentations in the discussion of an important measure. As a matter of fact, the only references in the reports of the Chief of Engineers to this subject which I have been able to find, are the following:

In the report for 1875, Vol. 2, page 172, reference is made to the paper of Wex, a prominent Austrian engineer who wrote an elaborate argument in favor of the proposition that forests exercise an important regulative in fluence, and the statement is made by S. T. Abent, U. Assistant Engineer:

This decrease is assigned to the devastation of the fo ests and the consequent decrease of atmospheric moistu —a cause often assigned but not yet demonstrated . . but whatever may be the causes operating there can little doubt as to the effect of the sediment brought dow by the annual rainfloods.

On page 510 of the same report Maj. Charles R. Sute then in charge of the improvements on the Mississip River, says:

The influx of sand *from above* must first be stopped then the river will have a chance to clear itself, an as its width contracts the shores can be revetted to pre vent any further injurious changes.

In the report for 1879, page 1211, Major Charles O Allen says:

The weight of evidence collected by various writer upon the subject of rainfall seems to indicate that re foresting of extensive areas of country is followed by a more equable distribution of the rainfall throughout the year.

In the same report, page 1373, Assistant Engineer T. P Roberts says:

The clearing of forest lands, I believe, is followed by greater fluctuations in our rivers. I think the storm waters undoubtedly reach the streams more rapidly now than formerly.

And in the report for 1891, page 1107, Major Charles W. Raymond, one of the most scholarly and capable officers who has ever been connected with the Corps, makes the following forcible statement, which it may be well to quote in full:

Causes Which Increase the Destructive Effect of Floods.

Such causes may be considered under the three following heads: (1) Destruction of forests and cultivation of land. (2) Artificial constructions, such as bridges and dams. (3) Collection of logs, lumber and ice in the stream and upon its banks.

(1) The destruction of forests from the mountain crests and slopes of a watershed *is undoubtedly the principal cause of the increase of the average magnitude of floods.* The evidence collected during the last 25 years establishing this conclusion *is well-nigh overwhelming*, and it is verified by repeated observations, not only in the mountains of Europe, but also in our own land. By the removal of the forests from the mountain slopes the ground is robbed of its protecting covering of roots, moss, leaves, and porous soil, which forms the forest floor and serves as a natural storage reservoir, holding back the water of rainfall and melting snow, and compelling it to descend slowly to the channels. By the subsequent cultivation of the lands, ditches and drains are made to facilitate the more rapid discharge from the cultivated surfaces, until the rain rushes down the hillsides in destructive torrents, gullying the ground and choking the minor lines of drainage with rocks, sand, and gravel, and hurrying into the recipient of the watershed volumes of water which before reached it in a comparatively quiet flow.

Colonel Torrelli affirms as the result of careful observations that four-fifths of the precipitation in forests is absorbed by the soil or detained by the surface of the ground, to be gradually given up in springs and gentle rills, and only one-fifth of the precipitation is delivered to the rivers rapidly enough to create floods. Upon the same slopes and surfaces denuded of their forests, the proportions are reversed.

That the destruction of the forests in mountainous watersheds is followed by disastrous floods where previously such floods were unknown is not a matter of theory, opinion or probability, but it is a well-established physical fact.

. . . The method of prevention by the maintenance and planting of forests upon the headwaters and upper slopes of the affluents of the basin depends for its efficiency upon the ability of forest-covered slopes to retain for a considerable time a large percentage of heavy rainfall, thereby preventing the surcharge of the lines of drainage. *In France, Italy, Germany and Austria the systematic planting of mountain slopes as a means of restoring lost fertility and preventing the inundations following the destruction of forests, is an established fact followed by results more satisfactory than the most sanguine anticipations.*

There is at least one officer of the U. S. Corps of Engineers who is acquainted with the teachings of experience.

Colonel Chittenden himself, the officer who has most recently written on the subject, apparently believes that the sediment carried by the Mississippi River into the Gulf of Mexico comes entirely from the mountain areas at the sources of the tributaries, for he says:

It must be clear from the foregoing that the bottom lands of the Missouri add nothing whatever to the total quantity of sediment that passes out of the mouth of the stream, for these bottoms have been increasing rather than diminishing in quantity. Likewise, the Mississippi bottoms contribute nothing to the volume of sediment that is carried *into the Gulf* of Mexico. It all comes from the uplands far and near, but principally from the more remote and hilly regions. This load is in the nature of through traffic. The local freight picked up from a caving bank is mostly discharged at the next station. It follows, therefore, that if the banks of these streams were revetted from the Gulf to Pittsburg, the Falls of St. Anthony, and the mouth of the Yellowstone, the quantity of sediment passing into the Gulf would not be diminished a particle.

In my previous discussion of Colonel Chittenden's paper,* I have shown, I think, the incorrectness of this statement. Any sediment washed into a river, whether from the uplands or from the banks in the lower portion

*This translation is not mine.—G. F. S.

[*Colonel Chittenden's lengthy paper on this general subject, with extended discussion, may be found in Trans. Am. Soc. C. E., Vol. LXII. (March, 1909), pp. 245-346. Ed.]

is gradually carried downstream and adds to the total volume of earthy matter that is being transported or moved by successive floods. . . .

Erosion.

The most important question connected with this whole matter is the effect of the forests on erosion, which has been already incidentally referred to. This matter Prof. Moore passes over with astonishing silence, and if it was his intention to offer a scientific contribution to the subject of the effect of forests, it is difficult to understand his reticence on this point. The fundamental principle is self-evident. The surface water running off from forest ground takes less earthy matter with it than the surface water from bare ground, from partially wooded ground, from grass land, or from cultivated land, especially on steep slopes. Land partially grown up in forests or bushes, or grass land, is of course better than cultivated land in this respect, but neither is anything like as effective as forest land. Forests, therefore, are the most efficient protection of the ground against erosion, and this is the strongest argument in favor of their preservation on steep slopes.

In the newspaper account of Prof. Moore's paper conclusions [are given under this head which do not appear in the official report—Ed.].

And in his argument before the Committee on Agriculture, March 1st, he stated that erosion was "a beneficient action." In his published paper, however, his conclusion with reference to erosion has been unaccountably omitted, and in his paper only about half a page has been devoted to this important subject as against fourteen pages to the entirely unimportant subject of the effect of forests on rainfall! In his paper he again befogs the issue on this point by bringing forward the argument that "every acre that will grow food for the people and thereby reduce its cost and furnish sustenance to the population and the teeming millions that are on their way to these shores, should be so employed." In other words, again "the pleading of the poor man's children for bread and meat" is allowed to stand in the way of the fair discussion of a great public policy.

Everybody knows that streams that flow from forested mountain areas are comparatively clear, while streams which flow from bare ground are comparatively muddy, and the efficiency of forests in preventing erosion of the ground is admitted by all competent authorities.

First in importance, then, is the effect of forests in preventing erosion; second is their effect in moderating, in general, the violence of floods and in maintaining a high low-water stage, and least or insignificant in importance is their effect upon climate.

Ratio of Mountain Watersheds to the Total Watershed.

Another claim put forward by Prof. Moore is that the ratio of the mountain watershed in a large basin like that of the Ohio River, is so small that the reforesting of the mountain area will be of little benefit.

. . . . . .

The immediate effect of deforestation on floods and on the deposition of sediment will clearly be felt first in the upper reaches of the streams; on the Ohio River, for instance, at Pittsburg and points above, rather than at Cincinnati, Cairo, Memphis or New Orleans. It is hardly fair, therefore, as Prof. Moore does, to compare the *mountain* watershed of the Ohio River with the *entire* drainage area of that stream. The mountain watershed is more fairly to be compared with the drainage area above Pittsburg, of which it would form a considerable proportion.

Before leaving this subject it may be as well to say that probably the best authorities upon it are neither meterologists nor engineers in general practice, but foresters and forest engineers, and that these are practically unanimous as to the value of forests. An engineer whose duty it is to maintain harbors and the navigable portions of streams, like the officers of our Corps of Engineers, does not, in the course of his daily experience, have much opportunity to observe or study forest questions. . . .

A volume could be filled with quotations from the writings of those who have observed this matter, but as an illustration only one will be given, from a review of a work published in 1901 on "Forestry in British India," by Berthold Ribbentrop, who has spent 34 years in the forest service. Statements like this should overbalance a thousand statements like those in the paper we are considering.

> In the Hoshiarpur district of the Punjab the Siwalik range of hills stretches from the Bias to the Sutlej River in a southeasterly direction. These hills consist of a very soft friable sandstone, alternating with strata of loam and clay. Formerly these hills were fairly well wooded. In 1846 they became British territory; the consequence was a rapid increase of population, a great demand for wood and charcoal in the fertile plains below, and the influx of a floating population of graziers with large herds of cattle. The result was complete denudation of these hills; the loose soil, no longer protected by vegetation, was washed down, broad rivers of sand spread into the plains below, and the end has been that fields and gardens of 940 villages, once properous, are now covered with sand, which has laid waste upwards of 70,000 acres of fertile lands. The district, rich formerly, is now traversed by numerous broad parallel sandy belts, cut out of the fertile and crop-bearing area.
>
> Efficient protection of the reserved forests was only commenced a comparatively short time ago, and yet the author is able to state numerous instances from different parts of the country, in which protection has completely changed the character of the torrents and streams taking their rise in the forests. After rain, the water no longer rushes down, carrying sand and silt with it; the channels have been confined into permanent beds; they have become narrower and deeper, and the old beds to the edge of the channel have become stocked with grass and thousands of seedlings. . . . The denser vegetation, which is the result of efficient protection, has everywhere counteracted erosion, has prevented landslips and sudden floods.*

This discussion is already too long, but before closing some consideration must be given to Prof. Moore's statement with reference to the question

Are Floods Increasing?

Professor Moore devoted 13 pages of his 36 to the discussion of this matter, in which he criticizes the discussion of Mr. Leighton of the Geological Survey, and of Messrs. Hall and Maxwell of the Forestry Service. His objections to the two papers are the following:

First: He claims that they discuss "not floods as such, but moderate stages of the river."

Second: He maintains that their method of discussing the observations is incorrect.

I have not at my disposal the records bearing upon this matter and therefore cannot, even were it desirable, here discuss them in full. Mr. Leighton's discussion of the Tennessee River compares the conditions existing in the twelve years, 1884 to 1895, with those existing in the twelve years, 1896 to 1907. Prof. Moore admits that this period of time is too short to allow of definite conclusions being drawn. He further says that "no records or other evidence are presented that there is not as much forest area in this basin as there was twelve years ago." The most that can be said, therefor, with reference to this discussion is that the evidence is not sufficient to justify definite conclusions either way. Personally, I think the figures given by Mr. Leighton indicate an increase in floods, but not having the full data at hand, and particularly no data as to the forested area, I believe this is simply another illustration of the fact that the statistical method is of very limited use, and perhaps of no use at all, in the case of meteorological and hydrological phenomena covering so short a period of time. Prof. Moore apparently takes the same view, for he says:

> No matter how complete the data may be or how fundamentally sound and fair their collation and grouping, the comparison, the one with the other, of such short periods as those measured by only twelve years, cannot give results with regard to changes in climate and floods that will permit the most skilled meteorologist or engineer to draw fundamental conclusions that can have any value.

If Prof. Moore had stopped here we could agree with him on this point. Unfortunately, however, he goes on to give what he considers a different and more reliable form of investigating this question of the relation of precipitation to run-off. For this purpose he takes the records of the height of the Ohio River at Cincinnati from 1871 to 1908, and from a consideration of these results he draws the following definite conclusions: (p. 33)

> The average discharge of the Ohio River, where, I presume, deforestation has been as great as in any other part of the country during recent times, has not changed for a period of 38 years except as caused by precipitation.

He draws this conclusion from the following facts:

	Ft.
Average stage of the Ohio River at Cincinnati, Ohio:	
1871-1889	17.3
1890-1908	17.5
Average precipitation in the Ohio watershed:	
1871-1889	41.3
1890-1908	41.8

Prof. Moore is apparently willing to draw definite conclusions from insufficient data where these data indicate to him that forests have no effect. He criticizes others for drawing definite conclusions where the reverse is indicated. Only on p. 28 he has made the remark, which is perfectly correct, that: "Precisely the same amount of rain falling in the two periods and no change whatever in forest or cultivated area, might produce largely differing results on floods"; and yet, because the average stage of the Ohio River in the two periods corresponds, in general, with the average precipitation, he concludes that "the average discharge has not changed except as caused by precipitation."

Now, the fact is, that Prof. Moore's figures give no indication whatever of the discharge of the river. He is evidently ignorant of the fact that a given river at a given place, when the water stands at a certain height on the gage, may be discharging much more or much less than it may be discharging at another time when the water stands at precisely the same height. Readings of gage heights are very inaccurate indications of discharge. The discharge of a stream depends not upon the gage-height alone, but also upon the *slope of the surface of the water* not upon the slope of the bed of the stream. A channel may have a level bed for a mile, but if the depth of the water at one end of the distance is greater than the depth at the other end, there will be a rate of discharge, depending upon the slope of the surface as well as the depths. On the other hand, if the bed of the stream is inclined, but the water surface level, so that the depth is different at the two ends, there will be no discharge. When a flood wave comes down a river, the front of the wave is steeper than the back, and when the water reaches a given height on a given gage, and is rising—that is, when the front of the wave is passing, the slope of the surface of the water will be greater and the discharge greater than when the crest of the wave has passed and the water stands at the same height on the gage as before. It is therefore fundamentally wrong to draw any definite conclusion with reference to the *flow of a river* merely from observations of the gage heights. It is equally incorrect, as Prof. Moore does, to draw any conclusions with reference to the increase in number and violence of floods from the number of days at which a river stood above a certain stage. In his testimony before the Agricultural Committee, Prof. Moore, when confronted with those facts, said that it made no difference whether the discharge was measured by a gage height or not, flood conditions were to be determined by the number of days at which the water stood above a certain height.

Now let us suppose that from 1865 to 1885 on a given stream, there were 40 floods in which the water stood above a given gage height at a given place, an average of four days for each flood, or 160 days in all; and that between 1885 and 1905 there were 80 floods in which the water at the same place stood above the same height an average of two days each, or 160 days in all, the same as before. According to Prof. Moore's discussion, the conclusion would be that the floods were not increasing because the total number of days at which the water stood above a given height had not changed.

I think it will be clear from the above remarks that Prof. Moore's figures prove nothing whatever. As a matter of fact, the effect of the removal of forests (reasoning now deductively) is unquestionably to increase the suddenness with which the flood waters are gathered into the streams. It is therefore fair to believe that such deforestation increases the number and suddenness of floods, diminishing also their duration. The damage done by floods clearly does not depend simply upon the number of days of flood. If an area is partly submerged it makes comparatively little difference whether the submergence lasts four days or ten days, the damage is not thereby increased perceptibly; but if, after one flood has subsided, there comes another one after an interval of a few months or a few years, although both may be short, the damage will be approximately doubled.

Other points in Prof. Moore's paper might be criticised, but this discussion is already too long, and they will be passed over. It is much to be regretted that the head of a presumably scientific department of the Government should, while claiming to be in favor of forest preservation, have produced such a paper as the one under consideration, the influence of which—so far as it has any influence—would be to discredit action which, as already stated, depends for its legality upon the effect of forests on the navigability of streams.

*"Nature," April 18, 1901.

FLOATING DOCK OF 8,500 TONS FOR LIVERPOOL.—A self-docking floating drydock of 8,500 tons lifting capacity has been built by Swan, Hunter & Wigham Richardson, Ltd. for Elder, Dempster & Co., of Liverpool. The dock is of the bolted sectional type, and has a length of 490 ft. by a breadth of 95 ft. The pumps are capable of lifting the maximum capacity in four hours. Mechanical side shores are fastened to both walls for assistance in centering vessels. Two swinging bridges connect the side walls for easy communication. The dock was designed by Clark & Standfield, of London, and was launched a short time ago, according to "Engineering" of March 18.

THE ORDER FOR THE PANAMA LOCK GATES covers no less than 58,000 tons of steel, distributed over 46 gates, or 92 leaves, of six different heights, as follows:

Height ft.	Height ins.	Number of leaves Gatun.	P. Miguel.	Miraflores.
82	0	..	..	4
79	0	..	16	..
77	0	32	..	16
66	0	..	..	4
54	8	4	4	..
47	4	4	4	4
Total 92 leaves:		40	24	28

The requisition, which was recently forwarded to Washington by the Isthmian Canal Commission, calls for manufacture and erection, except that about 8,000 tons of material already ordered are to be used by the contractor. Pound-price bids are called for ("Canal Record," March 23, 1910). There is a large amount of duplication in the work, as all gates of the same height are identical except in the case of the 47 ft. 4 in. gates, which have different footwalks when used as upper and as lower guard-gates, respectively. The design of the gates was described fully in our issue of Sept. 16, 1909, with drawings. The gate openings are 110 ft. wide, the leaves stand at an angle of 26° 33′ 54″ with a transverse line, and each leaf has a length of about 65 ft. over the hinge-blocks.

Widening the Floor of a Double-Track Masonry Viaduct.

The Paris & Orleans Ry. crosses the Cher valley near Issoudun by the St. Florent viaduct, which is a double-track masonry structure having 14 arches of 98.5 ft. span, with three spandrel arches between each pair of main arches. The total length is 1,720 ft. In the construction of a new secondary railway of meter gage, it was desired to utilize this viaduct for crossing the valley. For temporary purposes a third rail was laid in one of the tracks, and each railway operated a single track. To provide for the original double-track standard gage line and the additional narrow gage track it was necessary to widen the floor. The viaduct had a clear width of 26.25 ft. between the heavy stone parapet walls, with refuges 15 ins. wide at intervals. The method adopted was to remove the parapet walls, and to lay on each side a row of cantilever slabs of reinforced concrete, anchored by the concrete filling and carrying metal parapets conforming to the original architectural design. The width between parapets was increased in this way to 35.75 ft. The three tracks, however, are within the width over spandrels, so that the cantilevers carry only the walks for the section men and give the necessary clearance for trains.

The general arrangement of the old and new floor construction is shown in Fig. 1. This work is described by Mr. M. Verdeaux, Engineer of Maintenance of Way of the Paris & Orleans Ry., in a paper published in the December number of the "Revue Generale des Chemins de Fer." The execution of the work was complicated by the necessity of providing for the passage of trains of the standard and narrow gage railways.

The parapets were removed to the level of the old stone corbels, which are 8 ins. wide, and 13 ins. apart in the clear. The concrete slabs (Fig. 2) are 8.53 ft. long (11.8 ft. at the refuges), and 3.28 ft. wide. On each side of the slab is a rib 10 ins. wide, so that the two ribs of adjacent slabs conform in width and position with the one stone corbel upon which they rest. The inner ends of the slabs are anchored to concrete girders built against the backs of the stone corbels, and between these girders is the concrete filling of the bridge floor. Expansion and contraction movements had caused several cracks in the stone parapets, and the slabs are laid to allow for greater freedom of such movements, while the metal parapets are secured by fastenings which allow ample movement independent of the slabs.

Before commencing work, the telegraph line was shifted to a temporary line of wooden posts erected across the valley. The parapet walls being removed, the track on the upstream or east side was shifted as far as possible to the east, with its outer rail over the line of the spandrel wall. The other track (with the extra rail, and used only by the narrow gage line) was shifted to the middle of the bridge. The construction of the new cantilever portion of the floor on the west side was then carried on, the stone plinth course being removed and the concrete slabs set in place by a revolving crane on a portable track. This is shown by the upper section in Fig. 3. This west side being completed, the permanent narrow gage track was laid, the standard gage track was shifted to the center of the bridge, and the portable construction track was laid on the east side, as shown in the lower view in Fig. 3. The old material was hauled away in the first place on the standard gage track; during the second stage of the work it was handled on the narrow gage track and finally on the portable track. The work was done in 1907 and 1908.

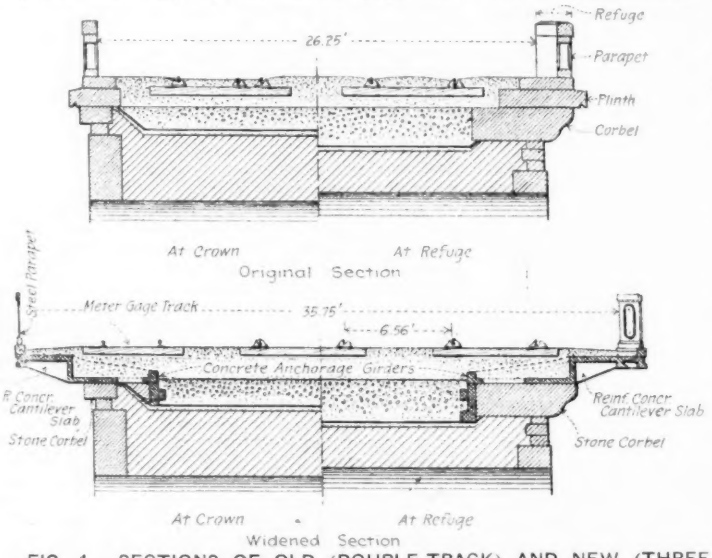

FIG. 1. SECTIONS OF OLD (DOUBLE-TRACK) AND NEW (THREE-TRACK) FLOOR CONSTRUCTION OF THE ST. FLORENT VIADUCT, PARIS & ORLEANS RY. (FRANCE).

A plant for the manufacture of the slabs was established near one end of the viaduct. The mold was placed on a solid floor, and the steel reinforcement (Hennebique system) set in position. Sheets of straw paper or packing cloth were laid in the end of the form for that part of the slab which would be exposed to view in the completed work. Two hours after pouring the concrete, the upper part of the mold was removed, and the face of the slab given a coat of fine cement mortar tinted to the color of the cut stone in the bridge. This avoided any subsequent treatment of the finished work to give the desired tint. In hot weather, the pouring and tamping of the concrete was done under a movable shed or canopy. The slabs were left in the molds for 10 or 12 days, or longer. The manufacture averaged ten slabs per day.

The slabs were run out on push cars on the portable track to the site of the work, and there handled by the revolving crane, suitable hooks being embedded in the concrete. The bed for the slab was wetted and then coated with cement mortar, in which the slab was adjusted by light blows with a rammer. To prevent the slab from tilting, while the projecting steel bars at the rear end were being interlocked with those of the horizontal and vertical members of the anchorage girder (A and B in Fig. 2), the inner end of the slab was loaded with bags of sand. The connections being completed, the concrete for these parts of the girder was poured. The bottom member of the girder (C, Fig. 2) had been constructed in advance, as soon as the necessary excavation had been made. Finally the rib (D)

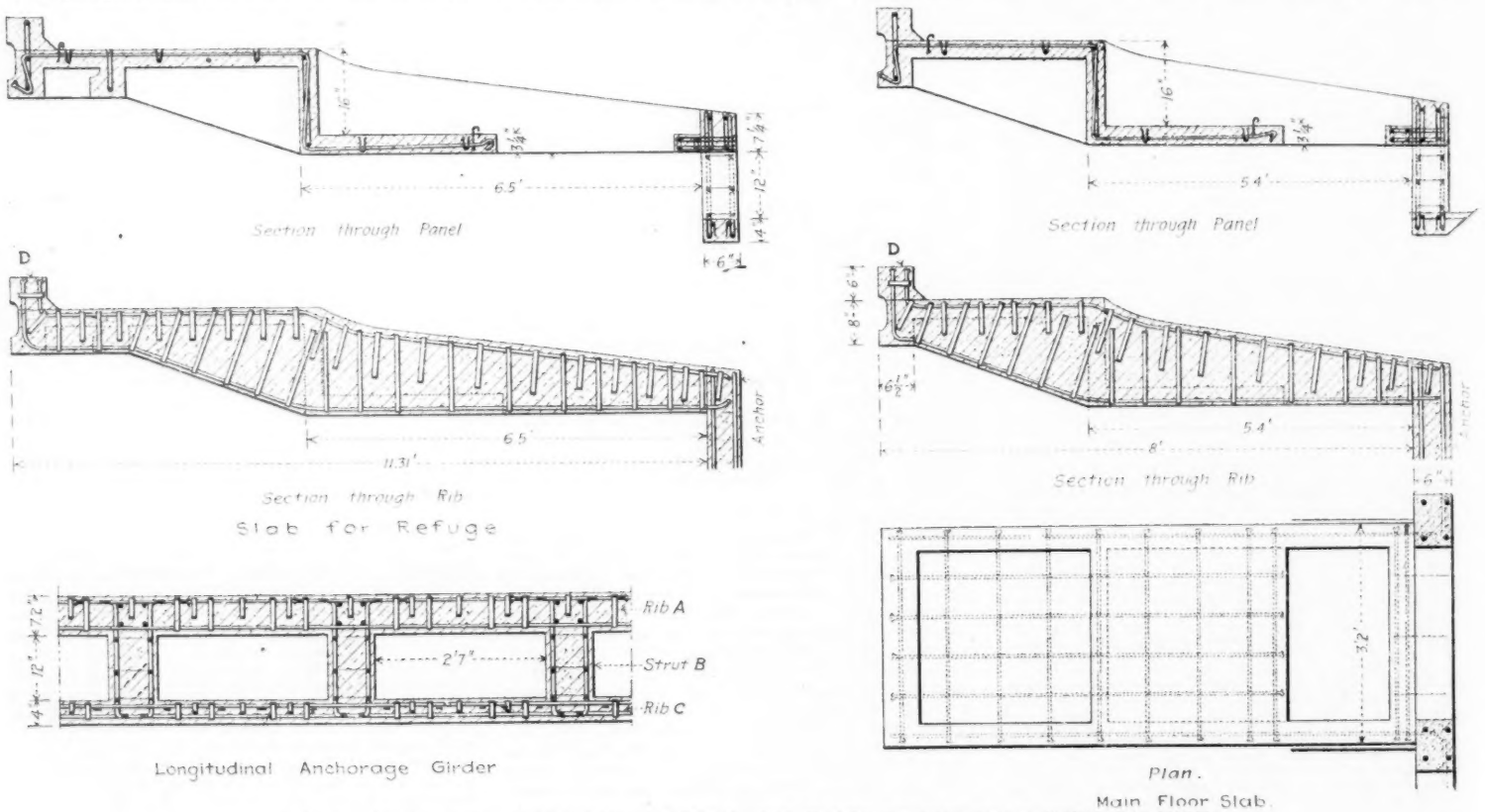

FIG. 2. CANTILEVER SLABS FOR WIDENING THE FLOOR OF THE ST. FLORENT VIADUCT.

was poured, forming the seat for the metal parapet. The final pointing and cleaning on the outside was done by means of a suspended platform. The work of construction extended over a length of 80 to 100 ft.

The removal of the old work, the construction of the new concrete work, and the manufacture of the metal parapet were done under three separate contracts. The shifting of the tracks was done by the railway company, and all the work was under the direction of Mr. Bouyssou, of the Paris & Orleans Ry.

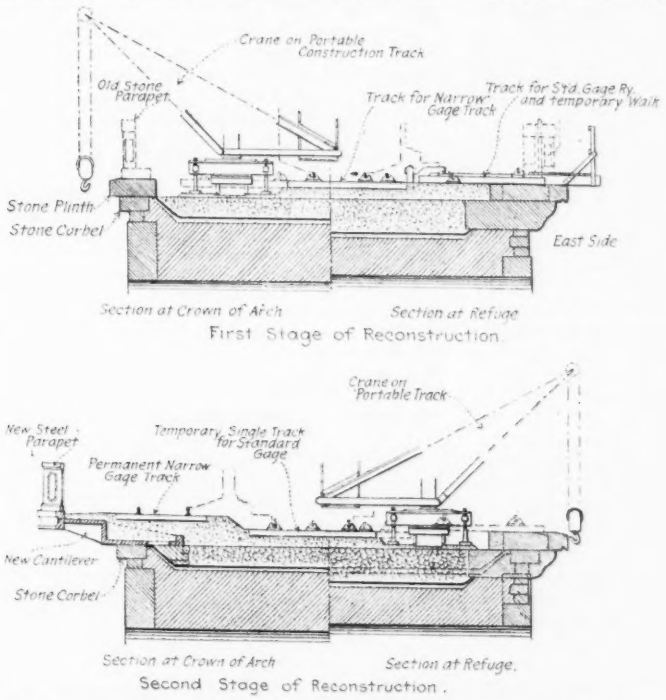

FIG. 3. ARRANGEMENTS OF TRACKS DURING THE RECONSTRUCTION OF THE FLOOR OF THE ST. FLORENT VIADUCT.

City Track Construction for Electric Interurban Railways.*

By H. L. WEBER.†

There are two plans that have proved satisfactory for track construction in city streets: (1) a sheet concrete foundation for both track and street pavement; (2) a crushed-stone foundation (grouted) for the track and a concrete foundation for the street pavement. With the former, traffic has to be suspended for one week at least on all new work to allow the cement to set, or else the cars must run over a temporary track, often with a great deal of expense to the railway company and inconvenience to the public. If there is a double track the service can be handled on one track while the other is being reconstructed. Or, with a sufficiently large number of crossovers, a third plan is to switch the traffic around the new work.

If new track has to be built in a city street, I would recommend a sheet concrete foundation for the track and roadway foundations, built at one operation. The track should first be laid, blocked up to grade and lined. The concrete, made very soft, can be then well puddled under the rails and under and around the ties with tamping bars. This part of the work must be done very faithfully by competent men, for upon their proper manipulation of the concrete at this stage depends the success of the work, whether steel or wood ties or anchors are used.

The purpose, of course, is to have the concrete one homogeneous mass when finished, and this can be accomplished only by having the concrete of such consistency that every particle of sand shall be coated with cement and every particle of the aggregate with mortar, all so mixed that the mixture will readily flow with slight agitation with the tamping bars in the desired direction to find the voids. When the concrete has set, it should be close up to the base of the rails, under and around the ties, forming a bearing for both.

In all concrete work, the art of proper mixing and depositing comprises the secret of good work. These two things must be done correctly and at the proper time to make the work a success. This is especially the case with street construction, for no class of work receives greater shocks and is more liable to failure from fatigue. The subbase can be reinforced when necessary by using the Carnegie rail section No. 90 S. This has a head 2¾ ins. wide, a base of 5⅝ ins. and height of 5¾ ins. This costs no more per yard than the 6-in., 73-lb. rail, although it weighs 20% more, and with the extra steel which it possesses no rail brace is necessary.

If paving bricks, wooden block or asphalt are to be used for paving it will not be necessary to have a greater depth of rail than 5¾ or 6 ins. If the steam roads find such a rail of sufficient strength, why should street railways use a deeper rail, unless the street paving requires it? I believe much money has been unnecessarily spent in providing too deep a rail and foundation, and in too deep a rail with too shallow a foundation, and that too little attention has been given to the proper draining of the subgrade foundation. It is far better to have a fairly heavy rail with a good foundation under the ties, than a rail of greater weight on a poor foundation.

In ballasted track, the rail receives the shock, transmits it to the ties, and the tie to the foundation. But is this true with concrete foundation, where the rails rest directly upon the concrete as well as on the tie? If the work of concreting has been properly done, the rails will have a bearing throughout their length, therefore a lighter rail could be used successfully than on ballasted track. On the other hand, if a rail should be adopted that will sustain the load without deflection, when supported on ties, say, 4-ft. centers, it will be strong enough, with a concrete foundation, for a great increase in the traffic loading. With a base 7 ft. to 8 ft. wide and sheet concrete 11 ins. to 12 ins. thick below the base of the rail and 6 ins. under the tie, there are few subgrades (when properly prepared) which will not sustain any load which either a steam or electric road has. If greater strength is necessary, the concrete can be reinforced.

A machine mixture of concrete 1 in 10 is preferable to a hand mixture of 1 in 8. All wet subgrades should be subdrained and all trenches thoroughly rolled or tamped before the track is laid so that the concrete laid may meet the maximum resistance. Sheet concrete when placed and made in the way specified, except that the mixture should be richer, can carry from 25% to 35% of rubble, boulders or old brick bats. In most localities in Ohio and Indiana concrete costs about $5 per cu. yd., so if 25% to 35% of rubble, etc., is added the cost of the concrete is reduced to that extent. Concrete of this kind was used on East Washington St., and cost only $3.07 per cu. yd. in place.

A track constructed with 90-lb. rails, white oak ties, 6 × 8-ins. × 7 ft., 35-in. centers, with suspended joints 21 in. centers, sheet concrete 7½ ft. wide and 6 ins. deep under the tie, standard angle splice bars, brazed rail bonds on the head of rails, brick paving and 1¾-in. sand cushions, will cost complete per lin. ft. of track about as follows:

Track material	$1.41
Track foundation and half excavation	.57
Pavement foundation and half excavation	.53
Brick paving complete	.79
Total cost per ft. of track	$3.30

A section of reconstructed track with a grouted, crushed-stone foundation was laid on Taylor St., Fort Wayne, Ind., in 1908, and I am informed by Frank M. Randall, city civil engineer, that the work is holding up well. The track was a single line, laid with 73-lb., 6-in. rail. During reconstruction it was necessary to excavate the street from 1 ft. to 3 ft., remove the old ties and rails and install the new material. During this work 50-ton interurban cars used the track under a 1½-hour schedule. There were also extra limited and express cars and a small city car service under a 15-minute headway. The city car service was at times delayed a few minutes, but the interurban cars had simply to operate under a slow order. A sufficient number of the old ties were removed so the excavation could be expeditiously done, and enough new ties were added to hold the rails to gage and make it safe under slow running. The tracks were then let down to the subgrade.

A trunk sewer had previously been constructed through a portion of the street. This portion was subdrained with a 3-in. tile. All trenches were examined, and if soft places were found or developed after a rain, they were filled with suitable material and rammed with the ordinary 45-lb. paver's rammer, manipulated by two laborers.

The outside of the rail, against the web, was filled in advance of the paving with a stiff concrete in the proportions of 1 part cement and 4 of sand. The 8 ins. of stone were put under the track in two 4-in. lifts. When the stone was in place, all the old ties were removed and the new ones were put in position. New rails were then laid. The track was then thoroughly tamped to grade four times. The men commenced at one end and continued through the entire length of the line, and a close watch was kept on all portions for apparently soft places. When the tamping was completed the crushed-stone foundation was thoroughly grouted for a distance of 15 ins. on each side of each rail with a Portland cement grout of 1 part cement and 4 parts good sharp sand.

Over the sewer trench 6 × 8-in. × 8-ft. ties were used, for the rest of the track 6 × 8-in. × 7-ft. ties. At the suspended joints the ties were placed 20 in. centers. There were 30 ties to each 60-ft. rail, making the spacing practically 24 ins. It will be noticed that one-third more ties, but less concrete, are required by this method of construction. The space between the ties, from the base of the rail to the bottom of the ties, was filled with a very soft concrete, consisting of 1 part Portland cement, 2½ parts sand, 2½ parts gravel, the gravel containing the sand and 5 parts crushed stone. The concrete was thoroughly puddled so as to fill under the base of the rails and around the ties, thus giving a bearing surface equal to twice that of the ties. The space between the rails and for a distance of 1 ft. outside the rails was paved with brick, with a special block on the inside of the rail to form the flangeway. An itemized cost of the work is given herewith:

COST OF STREET RAILWAY TRACK.

Track work and material—	Per lin. ft. of track.
Labor laying track and one-half excavation	$0.413
Ties	0.274
6-in., 73-lb. steel rails	0.700
Rail and cross bonds (compressed)	0.012
Bolts	0.004
Spikes	0.004
Splice bars	0.055
Total cost of track work per linear foot	$1.462
Track foundation, 8-in. crushed stone, grouted—	
Labor	$0.129
Stone delivered	0.231
Drain tile	0.011
Cement and sand for grouting	0.035
Total cost of foundation per linear foot	0.406
Concrete foundation for paving—	
Labor, including one-half of the excavation	$0.336
Stone delivered	0.114
Cement	0.114
Sand	0.028
For use of tools	0.013
Total cost of paving foundation, per linear ft.	0.605
Brick pavement—	
Labor	$0.114
Metropolitan paving block	0.505
Metropolitan special shapes	0.180
Cement	0.028
Sand	0.021
Track drains	0.005
Mixing boxes, etc.	0.004
Total cost of pavement per linear ft.	0.857
Grand total cost per linear foot	$3.328

Cost of concrete per cu. yd., $4.34.
Cost per sq. yd. of brick paving, including foundation complete, $1.946.
Length of track constructed, 2,332 lin. ft.
Brick pavement, 1,794 sq. yds.

A comparison of the work done on Columbia Ave. with sheet concrete and no traffic while the track was being built, and the work done on Taylor St. with crushed-stone grouted and traffic maintained, shows that the work on the latter street cost 6.4%, or 21 cts per lin. ft. more. The cases are very few where a temporary track could be built and maintained for 21 cents per linear foot.

The municipal authorities in Ohio make no provision for paving that part of a street which the railway company is required to maintain, except to declare that it is necessary to improve it. The company must either arrange with the contractor, who does the balance of the street, or must do the work itself, and must pay for the improvement at one time in either case. It is advisable for a railway company to do the paving itself, thus familiarizing its employees with this class of work. There is always work of this kind to be done in maintenance of way, and it is desirable to have competent men available.

*Abstract of a paper presented at the meeting of Central Electric Railway Association, held at South Bend, Ind., March 24.

†Chief Engineer; Columbus, Marion & Bucyrus Ry., Marion, Ohio.

FLOATING OYSTERS IN BRACKISH WATER is forbidden by an order of the Department of Agriculture, issued March 31. The order is made on the ground that oysters so treated are likely to spread typhoid.

A Mining Locomotive Driven by a Gasoline Engine.

While the presence of fire-damp in coal mines and need for good ventilation has generally prevented the use of mining locomotives with internal-combustion motors, yet the difficulties have not been insurmountable as is seen by the adoption of such engines at several mines in Austria and Germany. Messrs. Ironside, Son & Dyckerhoff, of Water Lane, London, E. C., have now designed such a type of underground machine which it is claimed possesses the necessary safety and in addition condenses the exhaust to a considerable extent. The accompanying figures show the arrangement of the locomotive, as pictured in the "Engineering Review" of London, March issue. The fuel may be gasoline, benzine, benzol or alcohol. No carbureter is used, but instead the petrol, after passing through a filter, is injected as a jet, with the necessary air, into the cylinder. The mixture is therefore formed inside the cylinder. As a precaution against the flame passing into the inlet pipes a wire-gauze baffle is placed in the inlet valve. A similar baffle is placed in the exhaust box. Water is injected into the exhaust box, near the exhaust valve, to keep the latter cool and to condense and absorb some of the products of combustion.

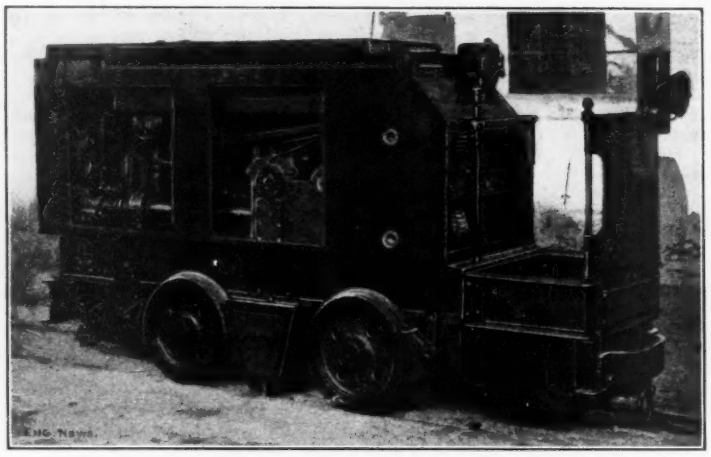

FIG. 1. A GASOLINE MINING LOCOMOTIVE.
(Designed and Built by Messrs. Ironside, Son & Dyckerhoff, Water Lane, London, E. C.

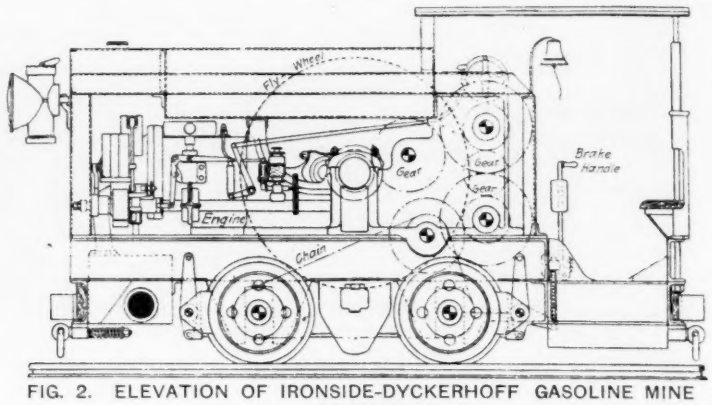

FIG. 2. ELEVATION OF IRONSIDE-DYCKERHOFF GASOLINE MINE LOCOMOTIVE.

The engine is connected to the driving wheels by gears and a link belt. Forward and reverse motion is secured by clutches operated from the cab. A brake lever works the heavy brake blocks shown. There is the usual form of sanding apparatus. Engine and transmission geafing are enclosed in a steel cab having doors and panels for inspection.

The locomotive is built in sizes of 6 to 50 HP., capable of hauling loads of 15 to 150 tons at speeds of 4 to 14 mi. per hr. The fuel consumption is stated to be about ⅔ of a pint of gasoline per horsepower-hour. The total operating cost is stated to be 1.2 cts. per ton-mile on the surface and from 2.4 to 2.6 cts. underground.

A 16-Story Steel-Frame Building to be Demolished.

The Gillender Building, at the northwest corner of Nassau and Wall Sts., New York City, a 16-story steel-frame office building erected in 1896, is shortly to be demolished to make room for a larger and taller structure. Thus an office building of most modern construction has made a record of short life, with but 14 years of existence. The case is the more notable because the Gillender Building is of unusual proportions, being very narrow and for its width exceptionally high. At the same time it is one of the most pleasing in appearance of all of New York's skyscrapers.

The building is about 26 × 75½ ft. in ground plan, and rests on a pneumatic caisson foundation. It has one basement story, and 16 stories above ground (a height of 241 ft. from curb to roof), capped by a three story tower, making the total height to top of finial close to 300 ft. The building being so narrow, its steel frame is only one bay wide; the columns in the walls are connected by transverse bracketed box-girders (in the rear end wall by lattice trusses) as wind bracing. The exterior facing is granite in the lower four stories, limestone in ten stories and terra cotta in the remainder. The tower walls are filled with brick and terra cotta, and the upper part is sheathed with sheet copper. The architect was Charles I. Berg. The steel-work was designed by Henry W. Post, of Post & McCord, contractors for the steelwork. The foundations were built by John F. O'Rourke, and the building itself was constructed by C. T. Wills. The building is still in as good condition as when new, and is taken down only in order to make room for a larger structure.

Three buildings adjoining to the west and one adjoining to the north have been acquired, making a plot about 100 ft. square, extending over Nos. 14 to 20 Wall St. and Nos. 1 to 5 Nassau St. A 30-story building is to be erected on this ground for the Bankers' Trust Co. Work will shortly be started on foundation construction and underpinning adjoining structures, this work being in the hands of The Foundation Company. The architects are Trowbridge & Livingston, and the building contractors are M. Eidlitz & Son.

The demolition of the Gillender Building is being carried out by the Volk Contracting Co., of No. 1 Nassau St. Work is to begin about the middle of April, and the contractor is planning to do the work in less than two months, a phenomenally short period. The removal of the steelwork has been sublet to Charles M. Seacomb, formerly superintendent for J. B. & J. M. Cornell. The steel will be kept not more than two stories behind the brickwork. It will be taken apart by cutting out rivets, keeping the members intact.

A CONCRETE JACKET FOR A LEAKY CONCRETE chimney has recently been placed at the plant of the Winchester Repeating Arms Co., New Haven, Conn. The chimney in question is 80 ft. high and cylindrical for a greater part of its height with an inside diameter of 4 ft. and a wall thickness of 4 ins. It was built about five years ago out of a dry, porous concrete and for some time past has given trouble owing to the cracks and holes affecting the draft. It was decided to jacket the whole outside with a 5-in. thickness of concrete reinforced with 32 vertical rods hooped with circumferential rods on 6-in. centers. For the work a form was built of sheet iron made up of three equal segmental parts and 5 ft. in height. The three parts were joined together by bolts through vertical angles on the edges of the segmental plates. To the forms a working platform was built and the whole contrivance hung by tackle from the top of the chimney and pulled up as concreting progressed.

A wrapping of asbestos felt was put around the old chimney to form an expansion joint between the old and new concrete and also to prevent the heat from the chimney drying out too rapidly the newly laid concrete. The construction followed a regular order; first 5 ft. of asbestos wrapping was plated, then the reinforcing steel, then the form pulled up over the section and the concrete deposited. The next morning, the process was repeated, so that concreting was always done in the afternoon and the forms removed from it the following morning.

The contractor on the work was the Aberthaw Construction Co., of Boston. It is described quite fully in a recent issue of "Power and the Engineer."

CONSERVATION OF CAPITAL.—(From the address of Jas. J. Hill at the Minnesota Conservation Convention.) The immense increase of wealth all over the world has greatly augmented the supply of capital. The mobility of this capital, the ease by which through international exchanges it can be made to satisfy a need, now in one country and now in another, strengthens the impression that it is inexhaustible. The increase of apparent resources by an easy resort to borrowing, the mortgaging of a patrimony not our own, to obtain material for present extravagance, the diversion of wealth from productive to unproductive uses—all these have gone further than most people realize.

The people of the United States inherited from its founders a wholesome tradition against debt, which is only now disappearing from the conduct of national affairs.

If the advocates of large bond issues for all manner of internal improvements should carry their point, if that resource is not definitely restricted to the emergency of war, we will be in the condition of Europe, where the motto of every chancellery now seems to be "After us, the deluge."

In our cities, modern extravagance finds its most untrammelled expression. The total debt of the States, including all minor civil divisions, increased $13,921,443, or 1.25%, between 1880 and 1890. Between 1890 and 1902 it increased $727,778,393, or 64%. Nearly three-quarters of a billion in twelve years, an average of $60,000,000 a year in the amount borrowed by the people, ought to make any country stop and think.

The growth of expenditure has so far outrun the growth of the country that the actual figures are almost incredible. The following little table, exhibiting the whole situation, might be printed at the top of every letterhead used by any man in public office anywhere in the United States:

	INCREASES. 1870 to 1890. Per cent.		Per cent.
Wealth	116	1890 to 1904	68
Foreign trade	99	1890 to 1908	85.4
Value manufactured products	121	1890 to 1905	58
Net ordinary expenses U. S. government	1.4	1890 to 1908	121.4
Expenses, 30 states	...	1890 to 1909	201.6

The phenomenal increase of public expenditure has already produced a plentiful crop of public ills. It is one of the causes of the increase in prices now disturbing the people.

Fortunately the remedy is not obscure. The ideal of intelligent economy must be restored. Let the rule be that every dollar unprofitably spent marks a crime against posterity, just as much as does the dissipation of material resources.

Credit everywhere should be conserved by a sharp scrutiny of new bond issues. The nation should reserve them for the crisis of war; no state need ever borrow again if it is wisely and honestly governed.

Stop grafting, the offspring of public extravagance and the parent of civic decay. Individual and public economy; a just distinction between a high standard of comfort on one side and vulgar ostentation or criminal waste on the other; a check on income-wasting, debt creation, and credit inflation—these are the essentials of the new and better conservation. The reform is so great, so indispensable, so linked to our moral as well as our material progress, that it would seem to appeal to the heart and mind of every American.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
BOSTON: 43 Tremont Street
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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How slow one American city is to learn from another! The system of selling water by meter instead of on the flat rate system has been in extended and successful use in many American cities for over a score of years. Wherever the meter system has been introduced, the old plan of charging a flat rate has never been reestablished. And yet, whenever it is proposed in any large city to extend the meter system, the same old, absurd arguments against the meter system which have done duty for more than a quarter of a century are trotted out to hinder the introduction of what every expert knows to be the only proper and equitable method of charging for water.

We have before us an item from the Pittsburg "Gazette-Times" of March 30, which states that an ordinance has been introduced in the Pittsburg councils, providing that there shall be a meter attached to every supply pipe connected with the city's water-mains. The newspaper remarks that, although municipal water-works experts favor the ordinance, it is opposed by saloon-keepers, livery-stable keepers, owners of small hotels, and brewers, all of whom complain that metered water costs too much!

It ought to be a simple and self-evident proposition that somebody or other has to pay for all the water that is furnished in any city water-supply. If the livery keepers, brewers, etc., use more water than they pay for by the flat rate, then the taxpayers have to foot the bill for the rest. Many an indictment has been brought against the liquor interests because of their part in opposing good government in our cities. It is an interesting question whether the waste of water in our large cities because of the non-use of meters may not be largely due to the opposition of the liquor interests.

We have remarked that cities are very slow to learn from each other's experience. If any city *is* willing to learn, however, certainly the experience of Cleveland is an object-lesson which cannot be overlooked. In the "Journal" of the Cleveland Engineering Society for March is a paper recording the results of the meter system in Cleveland, read on March 8 by Mr. Joseph C. Beardsley. He shows that by expending $1,400,000 on water-meters, Cleveland has saved already an expenditure for additional pumping machinery, mains, etc., that would otherwise have been necessary, which is conservatively estimated at $2,200,000. Mr. Beardsley combats the stock argument that water-meter rates are a burden on the people by showing that from 80 to 90% of the residents of Cleveland using water are to-day paying, on the average, one-half the money they paid for water under the flat-rate system. The total revenue of the water department has been reduced, but this has been offset by reduced expenses, and no more water is being pumped in Cleveland to-day than twelve years ago, notwithstanding an increase of 44% in population.

In the discussion, another engineer stated that, besides the direct saving on the water-works expenses, the water-meter system in Cleveland will ultimately save the taxpayers a large investment in sewer construction. The city's sewer system was designed for a population of a million, using 200 gallons of water per capita per day. The present prospect is that Cleveland will have a population of a million by 1938; but, as the water consumption is being held down to half that originally estimated, the sewer system will be large enough for double that population.

It is exactly ten years ago this week that the failure of the great dam across the Colorado River at Austin, Tex., was reported in the columns of Engineering News. That disaster created a sensation in the engineering profession which has been matched in few cases where engineering works have failed.

The dramatic circumstances will be readily recalled by many of our older readers. It will be remembered that the failure of that dam was heralded to the public at first as a reflection upon the engineering profession because some hydraulic engineers of eminence had been connected with the work. But when the whole history was investigated, it was found that the authority of the engineers had been so interfered with by the city officials in control that their responsibility had been practically nullified and one prominent engineer had resigned rather than have his name further connected with work which he could not control.

When the dam was completed, in 1893, it was an impressive work in external appearance, but there was something wrong with its foundation. It lacked the foundation of competent and conscientious personal responsibility. There followed what may be taken as a logical sequel: a month after the dam was completed it developed a crack from settlement at one end, and leaked badly. Very expensive repair work had to be undertaken. When completed, the dam was fit for service, so far as external appearance went; but its congenital defects remained. During the half-dozen years that the dam endured, unseen forces were at work, undermining the dam, eroding and dissolving away the soft, seamy rock on which it rested. They gave evidence of their work from time to time, but the warnings all were unheeded. Ultimately the dam had to fail. But again in the failure the dramatic proprieties maintained themselves, for the catastrophe came during an exceptional and very sudden flood, which wrought destruction almost before the existence of a flood stage was noticed. And the nature of the failure was in perfect keeping with the situation, being so peculiar, almost mysterious, that long-continued discussions ensued, concerning the why and the how, before the conclusion was accepted that the rock foundation (in its poorest part) had been weakened so much by steady progress of erosion that at last the dam was simply floated or pushed down-stream off its bed.

For just ten years the wreck of the dam has stood beside the city of Austin, a monument of its unfortunate beginning and disastrous ending. Now at last the dam is to be rebuilt. Naturally the new structure to replace one whose failure was so spectacular is of much interest to the engineering profession.

We present now an article based on data supplied us by Prof. Thos. U. Taylor (who ten years ago wrote for us the description of the failure) setting forth the terms of the contract under which the dam is to be rebuilt and the city is to be furnished with a new water and electric supply system.

Our readers interested in dam construction will find, we are sure, much to interest them in the plans proposed for the reconstruction. The plan of passing the flood-waters through mammoth sluice-gates, the location of the power-house machinery in the hollow interior of a section of the dam out near the center of the Colorado, subject to floods and backwater—these and other features in the plans indicate that whoever drafted them was not lacking in courage, whatever he may have lacked in other respects.

We forbear to comment, in detail, however, since details of the construction proposed are few; but the remarkable contract under which the dam is—probably—to be rebuilt deserves some attention.

The contract is an agreement under which the city buys a dam—and some appurtenances—on the instalment plan, at a price which appears to be extremely low. As to what kind of a dam and appurtenances the city is to receive, the contract is pleasantly indefinite. The plans accompanying the contract appear to be both incomplete and conflicting. There are no specifications binding the contractor to furnish any special kind of construction or quality of workmanship. The so-called specification is but a sketchy summary of the works to be built. The city can inspect the works, to be sure, but the inspection must be done by "an engineer agreeable to the contractor or his assigns." That clause alone should make this contract famous!

On the other hand, it is fair to say that inasmuch as the work is to be paid for on the instalment plan and the contractor has to assume risk and responsibility of operation and construction for twenty years, and finance the work, he has many incentives to build safely and permanently as well as cheaply.

From the past history of the Austin dam and of the difficulties met in attempting to rebuild it, it is probably correct to say that the city is farming out the work of engineering, financing and constructing a new dam and its adjuncts because better methods of carrying out the work were not feasible. It will be of much interest to see how the contractor will succeed in his onerous task. We have published a good deal about the Austin dam in the past 20 years; the prospect appears excellent that we shall have opportunity to publish more.

A fuel-briquetting plant in successful operation on a commercial basis is described elsewhere in this issue. Satisfactory machines for making fuel briquettes have been available for a number of years. The very type of machine used in the present plant was described among others in a comprehensive review of fuel briquetting in this country in our issue of Feb. 12, 1903. And yet the successful commercial manufacture of fuel briquettes has been until recently a thing almost unknown in the United States. Extensive experiments have been made from time to time and attempts at regular manufacture were begun as early as 1876, but until the last two or three years there has been in this country only an insignificant production of fuel briquettes on a commercial basis.

The recent history of the industry in the United States can be found in the publications of the Geological Survey. The earliest plants for which any regular production is recorded and which are still in use began operation in 1905-1906. There were only eleven plants in actual operation in 1907 and the total production reported to the Survey for the year was 66,524 short tons. The number of plants in operation in 1908 was practically the same. Not more than three or four of the existing plants have been continuously operated on a commercial scale during a period of as much as five years.

In Germany, where the fuel-briquetting indus-

try has made the greatest progress, the production exceeded 1½ million tons in 1901 and, according to "Mineral Resources of the United States," published by the Geological Survey, Germany's production in 1906 was about 16,000,000 tons. The remarkable growth of the industry in Europe suggests interesting future possibilities in the United States.

The growing practice on the part of many municipalities and a few water companies of acquiring a considerable part of the drainage area from which their surface water-supplies are taken, has opened up an opportunity for forestry work which has been embraced by a number of cities and, we believe, by at least one company. In our issue of Jan. 15, 1903, we gave some account of all such forestry operations that had come to our attention up to that time. We mentioned work which had then been but recently begun around the Wachusett Reservoir of the Metropolitan Water-Works, supplying Boston and vicinity. Elsewhere in this issue we reprint an interesting and valuable paper giving an account of this forestry work brought nearly down to date. As the author of this paper points out, forestry work in such instances affords an opportunity to utilize what would otherwise be waste land, or else land which if put to agricultural or pasturage purposes might be a possible menace to the purity of a water-supply. We hope to see that class of forestry work materially extended in the future.

A new way of securing public improvements without taxation has been offered to and accepted by the citizens of Hudson, O., according to press despatches which have been sent widely throughout the country. According to the statements, a Mr. J. W. Ellsworth offered to build water, sewerage and lighting systems, provided the town of Hudson would vote "dry," or against saloons, and keep it up for 50 years. The reports state that for the second time the town has voted "No license," and that the more recent vote was 162 to 97 against the saloons. It appears that the offer provides that if at any time within 50 years the town votes for license, then the public improvements provided without cost to the city will become the property of the heirs of the donor. Some question as to the validity of the offer, or at least of the stories regarding it, seems to be raised by reports that Mr. Ellsworth has also made it a condition of his gift that all the houses in Hudson shall be painted white and have red tile roofs, that hedges shall replace fences, all trees to be set equidistant, and all wires placed underground.

According to "Who's Who," Mr. Ellsworth is a capitalist residing in Hudson, and has been for many years an owner and operator of coal mines. He is building a model coal-mining town in Washington Co., Pa., to be called Ellsworth.

There have been several instances of private gifts of water-works plants and like facilities to municipalities, but none, so far as we know, so unusually conditioned as the one which we have noted. It seems to be a case of a town voting dry in order to be wet.

The extreme conservatism of the British Local Government Board could hardly be better illustrated than by its refusal to authorize bond issues of more than ten years' life for reinforced-concrete construction by municipalities. According to a letter in the London "Contract Journal," such a refusal has just been made in connection with an application for a municipal loan to pay for the erection of a reinforced-concrete tank. The refusal was all the more remarkable in view of the fact that the Admiralty War Office and the Board of Works and all national government departments, as well as various railway companies and other private interests, are using reinforced concrete in England to an increasing extent.

The attitude of the Local Government Board in regard to reinforced concrete is similar to the stand it took regarding the so-called bacterial methods of sewage treatment. Having gotten into the rut of requiring final treatment on land for the sewage, quite regardless of the treatment that had gone before, and of whether or not the land was at all suited for the purpose, the municipal authorities of England and Wales were held up to this requirement until the protests of municipal authorities and engineers led to the appointment of the Royal Commission on Sewage Disposal. Perhaps a royal commission on reinforced concrete will be required before the municipal authorities of England will be allowed to borrow money for reasonable periods to carry out a type of construction which has met the approval of engineers throughout the civilized world.

Bridges over Navigable Streams: The Interference of Water Traffic with Land Traffic.

In any question where public interests are affected, it is almost an axiom that the end which should be sought is to secure the greatest benefit to the largest number of people. There are, however, few public questions which are permitted to be settled on this basis. From one side or the other some vested interest steps forward and demands that *its* rights and privileges shall be maintained regardless of the effect upon others.

An excellent illustration of this warfare between the public interest and the vested interests is the construction of bridges over navigable waters. The plea that the greatest benefit to the largest number of people should be sought is a plea that has no standing in court. The navigation interests demand that the bridge shall be so constructed that the use of the waterway will not be interfered with. They require the length of spans and the height of the structure to be such that water traffic shall not be hindered. Little heed is given to the effect on cost of construction and on the movement of traffic over the bridge which these requirements may cause.

In the current discussion over the development of inland waterways, no mention has ever been made of the burdens which such waterways place upon land transportation, by reason of the necessary bridges. Millions of dollars are spent annually in the United States, in constructing draw spans and in building fixed bridges with higher floor levels and longer spans than would be required except for inland navigation. Besides this annual investment in bridge construction on account of water navigation, there is a heavy annual expense in the operation of drawbridges and in moving millions of tons of traffic up long and steep grades to pass over bridges. The public does not pay much attention to these items of expense because it imagines that this burden is borne by the railway companies. As a matter of fact, however, the burden eventually falls upon the general public.

Of course it is well understood that a considerable number of these navigation openings and high, long-span bridges must be regarded as a necessary evil, where a substantial amount of water transportation exists. On the other hand, there are a great many draw-spans over channels where the water traffic is a mere trifle and notwithstanding the steady decline in water-borne traffic on inland rivers, the tendency is to fix greater heights and longer spans over navigable rivers than were demanded 20 years ago.

One result of the waterway craze which is sweeping over the United States is the imposition of new demands with respect to bridges. The cry is, "Anything to benefit the waterways," regardless of what it may cost and regardless also of the burdens laid on land traffic.

A notable illustration of the extravagant demands made on behalf of the inland waterways is furnished by the bridges over the Allegheny River in the city of Pittsburg. There are five bridges over the Allegheny at Pittsburg, which have been built at different times. Until about ten years ago there was never any complaint from the river navigation interests as to the height of these bridges. Since then, however, notwithstanding the fact that traffic on the Allegheny had fallen off to a small fraction of what it was twenty to thirty years ago, the river interests have been clamoring to have all the bridges over the Allegheny River raised. This question has already been twice passed upon, once by Hon. Elihu Root when Secretary of War and later, in 1907, by President Taft when head of the War Department. In both cases it was decided that no necessity existed for raising the bridges. Nevertheless the question is still being agitated, and testimony has recently been taken by a board of United States Engineers.

It is interesting to compare the volume of traffic passing over the bridges and the river traffic which passes under them. From data furnished by a well-known Pittsburg engineer, it appears that on an average day 13 steam boats pass underneath the Sixth Street bridge. During that time there passed over the same bridge 30,000 pedestrians, 1,600 street-cars carrying 55,000 passengers, 1,700 carriages and light wagons, 500 automobiles, and over 1,000 heavy wagons. The Secretary of War has ordered that this bridge be rebuilt with a single channel span of 445 ft., having a clearance of 47 ft. above the pool level. The present bridge has a clearance of about 34 ft. The approaches to the new bridge would have a grade on one side of 4.57% and on the other side of 3.95%. Putting entirely one side for a moment the great expense of rebuilding this structure, this means that all this huge traffic would have to be lifted an additional vertical height of 13 ft. in crossing the river.

This, however, is only one of the bridges affected. If the increase in height were to be of any particular value, all the other bridges would have to be raised likewise and the traffic over them would be subjected to a similar burden. A correspondent, whose letter we print in another column, well sets forth the difficulties which such grades oppose to the movement of loaded wagons. It would mean, reduced to dollars and cents, an added burden on the traveling public of many thousand dollars a year on each of the bridges which would be affected.

Let us now inquire, on the other hand, what benefit the river traffic would receive from the increased clearance. It should be understood that at low water the present bridges are no obstacle to traffic in any ordinary-size steamboats. Furthermore, the most sensible advocates of river navigation agree that barges and not steamboats are the most economical method of transport on inland waterways. There is no difficulty, certainly, in passing barges of any reasonable capacity under the present Pittsburg bridges. The river advocates claim, however, we believe, that at high stages of the stream there is not sufficient clearance under the bridges. Let us see what this actually amounts to as an obstruction to river traffic.

The U. S. Weather Bureau records at Pittsburg show that for the past twenty years the water in the Allegheny has been at a 16-ft. stage or over, less than ten days per year, on the average. It reached this height a little over four times a year, on the average, and remained at 16 ft. or more a little over two days each time. Even at a 16-ft. stage, there is 24 ft. head-room under all the bridges below the Fort Wayne railroad bridge, and under some of the bridges above. Of 13 towboats now operated in the Pittsburg pool, only one has a height of 24 ft. above the water.

We do not see how it can possibly be claimed, on this showing, that the present bridges over the Allegheny offer any actual obstruction to navigation. On the other hand, to raise these bridges would require not only a very large expenditure in alteration and new construction, but, what is more important, it would impose a heavy burden on all the enormous traffic passing over these structures.

We have reviewed the situation at Pittsburg, because it is, we believe, typical of a widespread infringement upon the public rights and public welfare which is being carried on under the plea that the waterways must be protected. Is it not time that a more sensible view of such matters was taken? Sooner or later the public is bound to raise a protest against continual yielding to the demands of vested interests. Sooner or later the

absurdity will become manifest, of stopping the entire passenger travel in and out of a great city like New York or Boston or Philadelphia or Chicago to let a scowload of potatoes pass through a drawbridge. Is it not time that the good old rule which we quoted at the outset, seeking the greatest good to the greatest number, was given some attention in the solution of traffic problems.

LETTERS TO THE EDITOR.

"Freight Handling by Machinery"

Sir: In reference to the letter in Engineering News of March 24 on "Freight Handling by Machinery," signed "Division Superintendent," I would say that it is by such criticisms that it is possible to arrive at a correct understanding of seeming objections.

This letter from the Division Superintendent also demonstrates clearly the necessity of engineering consultation, after a study of the location, with exact designs and specifications. All of the subjects mentioned have been carefully considered and provision made for each condition as described.

At the present time it is impossible to buy any one machine for L. C. L. freight handling, install it and expect the best results and economy. It is necessary for the machinery to be a combination and adapted to the different classes of work. Generally it is the product of several manufacturers, and it is often a mistake to try to use all the machinery from one manufacturer because he has happened to manufacture in the past something which, after a fashion, could be modified to do part of the work.

At some freight terminals it is necessary to have the machinery overhead; at others, a combination of overhead carriers and motor trucks upon the surface, or platform cars upon adjacent tracks; in others, underground tunnels could be used to advantage, and in some cases belt conveyers.

A careful study, based upon experience and the knowledge of what each class of machinery can do, will result in success, the avoidance of congestion, and will greatly increase the capacity of a terminal. The different conditions to be met have different values, according as the point of view is from an operating or from an engineering standpoint.

The following, written a number of months ago by the undersigned, indicate the position taken by the writer as to the criticisms:

Requirements Which Must Be Fulfilled by Any Mechanical System.

With respect to the importance of careful checking: According to present requirements, the dray loads of packages must be arranged into separate and individual piles. This is now done by the draymen and unloaders. The unloaders are often furnished by the railroad company. Each pile represents a different consignee, with the marks of the packages, especially that of the top package, showing plainly. If to one consignee there should be more than one classification, there should be a separate pile with the marks on top for each. The pile of packages for each consignee should be inspected for condition as received from the drayman, counted and receipted for by the receiving clerk. Each pile should pass to the scales; the name, destination and number of packages being given to the scale men by the callers standing at the scales.

The waybills, which are generally in triplicate, are checked after having been previously arranged in alphabetical order by the weigher, each individual load being duly checked and the weight stamped upon the waybill. If whole dray loads of the same classification be for one consignee, the whole load could be inspected, counted, hoisted, weighed and conveyed directly to the proper car by mechanical methods, there being a shell crate or flat board on the truck furnished by the consignor. The consignor's truckman would be detained in such a case but a few minutes. His load under such conditions could be conveyed directly to the scales after inspection and counting.

The conveying mechanism, whether man or machinery, receives a tag showing the number of the car, the number of packages, and the serial number. The conveyor mechanism carries the load to the car, the checker punches the slip and the conveyor brings back the slip to the box boy, together with the number of the car, which is taken from a box alongside the car. The checker boy sees that they correspond and puts them in the proper box.

It is important to state that any mechanical system, whether electric overhead or other methods, should enable not only all of the above conditions to be fulfilled, but should provide for other checks, which will reduce even more the liability of sending a package to the wrong destination.

In one special freight shed overhead tracks would be used and consist of fixed circuit tracks in front, crossover by-path tracks arranged in pairs and movable so that they can be adjusted to the most economical conditions of receiving and forwarding the freight. Between each pair of cross-over tracks, and at each end, are located the weighing booths and a platform for the man to call out to the weighers the name of the consignee, destination and the number of packages. The carrier-hoists with the loads pass from the long lead track to the scales and to the other side of the circuit track.

Flatboards and Flatboard Trucks in Reference to Their Careless Loading.

The construction of the flatboards will vary according to the individual preferences of local superintendents. In general they consist of flatboards securely bound with iron, having sectional, detachable chain or rope net sides. These nets are so adjustable as to accommodate themselves to packages which may extend beyond the sides or ends. In the case of careless loading these nets are a secure safeguard against packages falling off. The hoisting is automatically stopped, the same as in elevators or in numerous telpher plants at manufacturing establishments.

The flatboard-truck consists of a truck with many of the characteristics of the present hand truck but with two wheels at one end and a handle at the other. It is similar to the two-wheeled truck which is commonly used, but with wheels of smaller diameter. It is not over six feet in length, so as to be easily manipulated in a freight car. It is necessary that the truck be near the floor or that the front of the truck can be tipped to meet the box or case, the action being like the hand truck in this respect. Most of the freight can be taken directly from that portion of the interior of the car in front of the car doors.

In a treatise by Mr. M. L. Byers, entitled "The Economics of Railway Operations," p. 518, fourth section, he says:

> In reference to the movement of the truck by the truckman to the car which is to be loaded, the truck is left near the car door, and the truckman returns with an empty truck, generally to the nearest scale. In some cases, the truckman himself places the freight in the car, but as a rule the work is better and more cheaply done where the work of the truckman is confined entirely to the moving of the loaded and the empty trucks between the scale and the car door.
>
> In such a case as this, no additional men would be required for receiving or unloading the freight than at present. As one telpherman does the work of sixteen truckers, great saving is self-evident.

In the valuable book which is used for railway education, entitled "Railway Organization and Working," by Mr. Earnest R. Dewsnup, he states that at a large station in Chicago where they have 140 truckers they only use 30 stowmen, one for each run of seven cars. This is on p. 144. At one place, it was estimated by the engineers that where 90 cars were being loaded, that there might be required 9 additional men in all. This was estimated to add to the cost of conveying 1.6 ct. per ton.

We have therefore data where the truckers leave the loaded truck alongside the car, and return with an empty, also the cost of the extra men per ton, as shown above. From the above, and from other deductions from experience in loading cars along the New York water front, the additional expense for this stowing per ton can be closely ascertained.

As shown above the mechanical appliance does bring back the slip to the transfer clerk, and special attention was given to this important feature; in fact, it was most emphatically emphasized.

The Smaller Freight Stations.

The cost of the installation within reasonable limits is proportional to the tonnage handled, and the saving on a small tonnage will pay a good interest percentage on the investment. Provided the plant is properly designed and installed, the saving on one hundred tons per day will yield a fair return and be a factor in increasing the efficiency of the whole transportation system.

As to the statement that the saving is only in the movement, the following will show its fallacy. Mr. M. L. Byers, chief engineer of maintenance of way of the Missouri Pacific Railway, has given some valuable data pertaining to interest and depreciation, etc. He ascertained that the cost of some 30 freight stations, including tracks and driveways, was about $12,000,000 and in these 1,000,000 tons of freight were handled per month. Of this, 400,000 tons consisted of house freight (L. C. L.) at an average expense per month of $166,000 for station forces and switchmen, to which should be added $104,000 for interest and depreciation. The above figures result in the following handling expense per ton:

Fixed charges and amortization	28.6 cts.
Labor and car shifting	41.5 cts.
	70.1 cts.

Let E equal expense per ton of freight handled by machinery, U the number of unit movements per minute, and L the load carried at each unit movement. The interest on the investment costs for machinery, taking into consideration the increased tonnage handled, has not in any instance yet figured, equalled 2 cts. per ton. It is generally about 1½ cts. per ton. This amount of 2 cts. added to the above figures gives $E = \frac{28.6}{U\,L} + 2$.

All the data of Mr. Byers were derived from stations using the hand trucks and manual labor.

It has been shown in a previous article that machinery will more than double the number of unit movements and double the load. On account of this doubling of both U and L the expense of freight handling, which should be charged to investment and amortization would be $E = 28.6 \div 4 + 2 = 9.15$ cts. per ton instead of 28.6. That is, doubling the unit movements and doubling the weight, by means of the installation of machinery, it is possible to handle more than three times the same amount of freight with the same investment. If only U or L be doubled, and not both, then the investment cost per ton is reduced by about one-half.

It will be seen from the above that the reduction in the cost per ton moved by mechanical methods applies equally well to the salaries of the superintendents of terminals, foremen and others, even though this salary is a fixed quantity.

If package or L. C. L. freight, to which this letter refers, passes through one transfer station, it has to be handled three times; four times when it was formerly taken to a transfer platform or house and assorted. Freight often passes through two transfer stations; this means four handlings. Each manual labor handling would cost from 35 cts. to 40 cts. per ton, therefore four handlings would cost four times the above figures. To these figures must be added the 28.6 cts. per ton for interest and amortization at the receiving and delivery stations, and also another percentage for the investment in transfer stations. I hesitate to add them up. They seem incredible, but the figures are correct.

Do railway executives know what are the total expenses for a ton of L. C. L. freight at terminals and transfer stations, from the first receiving to the final delivery? I cannot believe that they do, for in some cases there is a loss per ton due to terminal expenses, but this is covered up in the general average.

There are other figures to be added to the above, due to damage claims for breakage at each rehandling, thefts, wrong routing. These figures are now being prepared. It is important to know that the claims paid for damages due to breakage alone from handling, for one road for one year, amounted to 2% on the total freight receipts.

Respectfully yours,
H. McL. Harding,
Consulting Engineer.

20 Broad St., New York City, March 28, 1910.

A New Plan for Preparing City Budgets.

Sir: The enclosed statement, summarizing a proposed new policy in budget estimates and appropriations for municipal maintenance work in the City of New York, involves a rather radical departure from systems heretofore in vogue, and it may be of interest to your engineer subscribers engaged in municipal work.

Yours very truly,
George Cromwell,
President of the Borough of Richmond.

Borough Hall, New Brighton, New York City, April 1, 1910.

ECONOMY IN MUNICIPAL EXPENDITURES.
A PROPOSED NEW POLICY FOR NEW YORK CITY.

Economy in the administration of New York city affairs depends upon two factors: First: The judgment of the Board of Estimate and Apportionment in appropriating moneys. Second: The efficiency of the departments or offices in the expenditure of such appropriations.

The present tendency of negation, suppression and checking in the administration of city affairs is opposed to efficiency; affirmative, progressive methods are conspicuous by their absence, except where contracts are performed for the city. Maintenance appropriations provided for in the segregated budget limit expenditures, but at the expense of efficiency, and it has been the experience of industrial organizations that efficiency is absolutely essential for economy. The old idea that men should be paid for hours of labor instead of work performed is one of the great causes of inefficiency. Fixed salaries, stated hours of work, rules, penalties and the like provide no incentive for interest on the part of city employees; thus the standard of efficiency tends to remain low.

This negative principle must be changed if real progress and economy in city government is to be attained. It is suggested that hereafter in New York city appropriations be considered and authorized upon three principles:

FIRST—Lump sum departmental or office appropriations shall be authorized when founded upon unit cost data and work requirements.

SECOND—In any department where such cost data is available, several salary grades for the same class of work shall be established by the Board of Estimate and Apportionment, so that the head of a department or office may increase or *decrease* wages within such specified limits, basing such action upon predetermined standards of work and efficiency records.

THIRD—Each head of a department or office in which fundamental cost data are available

shall have direct responsibility in the expenditure of appropriations, the results attained being checked by some independent authority such as the Mayor, acting through the Commissioners of Accounts, or the Comptroller.

The adoption of the foregoing principles would eliminate the present segregated budget in offices where the unit costs of work performed are known and modern methods of advanced planning, standardization of duties, prompt rewards and punishments of employees for results accomplished, cost recording and cost checking would obtain. Economy in maintenance expenditures would inevitably result if this system is properly carried out. Appropriations for fixed amounts of work would tend to decrease as efficiency increased. Salary questions, which are great sources of trouble in the Board of Estimate and Apportionment, would be automatically adjusted when standards of work are fixed, particularly if decreases as well as increases in salaries become the rule. The old difficulty with lump sum appropriations in the past will disappear when work costs and work data are available, and subject to check by an independent authority. Wages will be paid for work performed instead of hours of labor, and every inducement will be offered to economize in the purchase of supplies, the payments for repairs to plant, and in fact all other charges which tend to increase unit costs of work, and therefore, budget appropriations. Comparisons of results attained in the same kind of work would be made year by year and a profit or loss balance would indicate efficiency of the particular department or office.

[We are informed that President Cromwell has been working on this system for some time past, and that most of the bureaus in his office possess fundamental cost data covering a number of years and pertaining to different classes of public work performed. He has proposed to the Board of Estimate, that a test or trial of this method shall be carried out in his department during 1911.—Ed.]

The Influence of Forests on Climate and Floods.

Sir: I beg to dissent—from personal observations—to the accuracy of the conclusions reached by Dr. Moore (Eng. News, March 3, 1910) in relation to the mutual effects of forestration and precipitation.

In Paragraph 2 of his conclusions, his statement that forestration has little or no effect on precipitation, I regard as erroneous and misleading. I have personally, for a number of years, given close observation to rain distribution in the Hawaiian Islands, and noticed the precipitation of the wooded northeast slopes of those islands varied from 100 to 200 ins. yearly, while the bare denuded southwest slopes have a rainfall of only 10 to 20 ins.

The conclusion in Paragraph 3, I must also dissent from, as I have noticed wherever much forest was removed from the northeast slopes above mentioned, for the purpose of cultivating the land in cane, there was a marked change in the local precipitation. Instead of presenting a cool, damp, condensing surface to the clouds moving from the ocean, such as exists with the natural forest cover, the cultivation of the soil for times destroyed all vegetation and made a bare, denuded surface, which absorbed the sun's heat, and made a layer of warm, heated atmosphere immediately above. When the vapor-laden clouds, coming in from the ocean, impinged against this atmosphere, they were elevated by its reheating influence and drifted off without being precipitated.

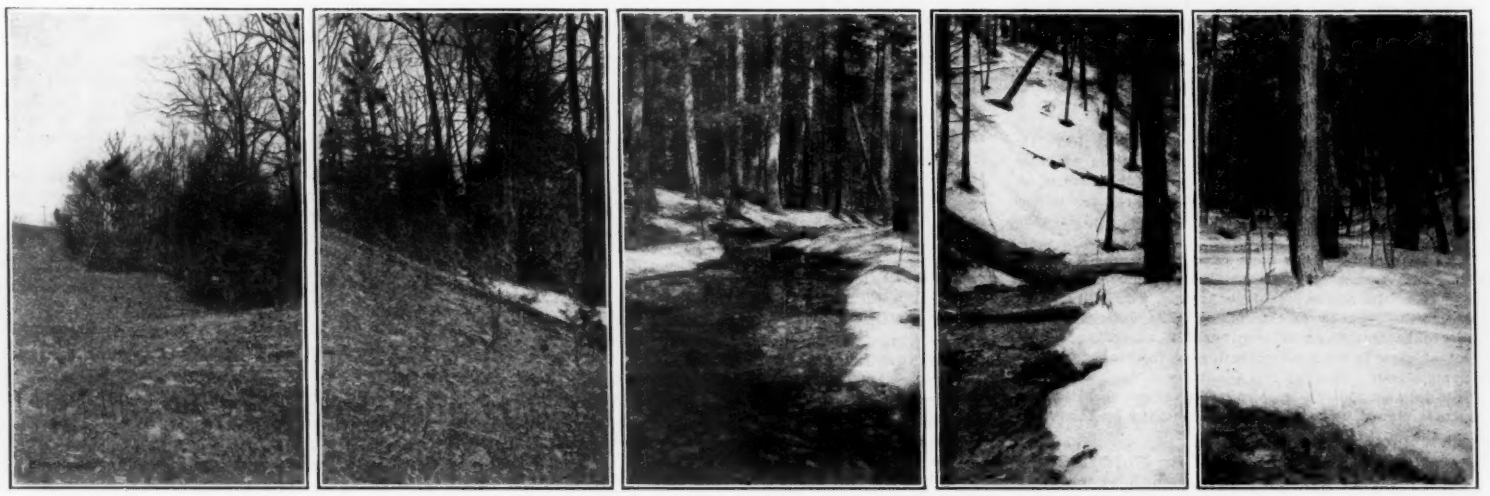
I have further to state that when the earliest white settlers first saw the Island of Molokai, seventy years ago, it was evergreen from dense vegetation; the advent of goats and other animals incident to civilization destroyed this growth, and the island gradually became denuded of forest and its green cover, and the surface became dry and barren. All the old inhabitants say that the rainfall is much less now, due to the changed conditions and absence of forest, than it was fifty years ago.

The facts above referred to are exclusively insular and local in character, but it does not require any strain of the imagination to realize that continental regions can be influenced by similar conditions.

I think it deplorable that an official of the United States Government, the influence of whose opinions are far-reaching, and having control of such an important department, should take such a partisan stand on a doubtful question and come to premature conclusions on a subject which is certainly still open for discussion.

There is no doubt that the planting and propagation of forests should be encouraged in every way for future fuel and industrial uses, which are essential for the prosperity of the country, and the survival of its inhabitants, and, in my judgment, it is a poor policy for a man of Dr. Moore's standing in the scientific world to adopt such a partisan and prejudiced position on a subject of such moment. Very respectfully,

M. M. O'Shaughnessy,
Chief Engineer, Southern California Mountain Water Co.
San Diego, Cal., March 22, 1910.



Views at the Edge of the Forest Showing Open Fields within 500 ft. of the Snowbanks Shown in the Views at the Right. — Views Taken in the Forest.

THE EFFECT OF FORESTS TO RETARD THE M ELTING OF SNOW, PHOTOGRAPHS IN HARDENBERG WOODS, STONE RIDGE, N. Y., MARCH 21, 1910.

The Retarding of Snow Melting by Forests in the Catskills.

Sir: Col. H. M. Chittenden, in a paper presented Nov. 4, 1908, to the American Society of Civil Engineers, upon the relation of forests to stream flow, absolutely denied that forests prolong the melting of snow. I quote from his paper as follows: "It can be definitely demonstrated that the effect of forests upon the run-off of snow is invariably to increase its intensity." This conclusion he reached from a study of the high mountains of the West, but he also made this statement about the eastern forests: "It is strictly true that the open-country drifts outlast the forest snows just as the latter outlast the thin snows in the open."

My conclusions, based on observations through four winters in Ulster County, N. Y., are entirely different from those reached by Col. Chittenden. I have resided in the Rondout Valley, which lies between the Catskill and Shawangunk mountains. The bottom of the valley is mostly cleared land; but the slopes are about 50% wooded, giving a very good opportunity to observe the melting of snow in the woods and in the open fields adjoining. During the first two winters I formed an impression that the snow accumulated to a greater depth in the woods and much outlasted the snow in the open. When Col. Chittenden's paper appeared, I determined to investigate further. The winter of 1908-9 was very mild, however, and the snowfalls were all of short duration. But the winter just past has furnished plenty of snow. Heavy snow fell on Christmas Day, with high winds and much drifting, and a long succession of storms followed. The sleighing lasted about ten weeks, and there lay in the open about two or three feet of snow, with many drifts along the roads running up to 5 ft. or more.

Early in February there was a heavy thaw, creating a freshet which took the thick ice out of the creek in a high flood. But most of the snow outlasted this and other snow-storms came, cold weather lasting until Feb. 26. At the end of the month came warm weather and rain. This melted the snow in the open with great ease, so that after two or three days of thaw accompanied by rain and fog most of the snow was gone from the fields, what remained being confined to drifts along walls and fences and snow in the shelter of hedges, etc. It was apparent, however, that the snow in the woods was far from gone, a glance at the hillsides showed solid snow in the woods and bare ground in the clearings. Upon investigation, the snow in the woods averaged 18 ins. in thickness, while the drifts in the open, if leveled off, would not have coated the bare fields with 3 ins. of snow.

During the thaw it was noted how rapidly the fog melted the snow. The woods, by retarding the wind, sheltered the snow from these warm fogs. The weather cleared by March 3, the days being warm and sunny, with cold nights until April. By March 14 the drifts in the open had almost gone; they would not have made an inch of snow broadcast. In the thin woods the snow had largely gone from southerly slopes, but much remained in the dense woods and woods on northerly slopes.

On March 21, after over three weeks of steady thawing, the accompanying photographs were taken in Hardenberg woods near Stone Ridge, N. Y., Lat. 42°. They show not more than 500 ft. away from the snow-covered woods fields with exactly the same exposure were absolutely bare of snow, even the heaviest drifts gone. Warm, dry breezes like those of June circulated over the fields, while within the woods the air was chill and damp. The residual snow even at the beginning of the thaw was noted to be a fine ice gravel, and through this mass the water from the melting surface easily reached the ground. A test showed this snow to yield about 40% of its volume of water.

Rondout and Esopus creeks ran swiftly during March, with clear, green water from melting snow. March 21-26 were very warm, at midday 80°, and the two streams became much swollen, although still clear and far below a dangerous flood stage. By the end of March the snow was nearly all gone, even in the mountains, and the creek sank to a very moderate flow maintained by ground water.

It seems to the writer that the above observations justify the conclusion that forests exert a very beneficial effect on the run-off from melting snow.

Very truly yours,
Lazarus White.

Stone Ridge, N. Y., April 4, 1910.

Forest Culture Not Opposed to Agriculture.

Sir: In your issue of March 3, 1910, there is an article by R. C. Beardsley, Consulting Engineer, in which he makes the following statement:

According to Government statistics a forest crop should net about $3 per acre, a small part of what the land should yield, were it farmed. Forests retard civilization. Highways and railroads are seriously injured. Forest fires destroy the growth of a century and cost many lives. Then why advocate forestation? Forestation is

only advisable when cultivation will not pay, and at such places only.

I am surprised that a consulting engineer should be willing to appear so ignorant of the aims of the present forestry movement as to assume that any forester advocates forestation of land which would pay better under agriculture. I am enclosing two photographs illustrating the character of thousands of acres of land throughout New England from which the owners are deriving incomes of less than 50 cts. an acre a year as pasture. There are other thousands of acres of cut-over and burned-over forest lands which are bringing in scarcely enough to pay the taxes. If any one thinks that by improved agriculture he can realize more than $3 an acre on these areas, he will have no difficulty in acquiring the lands at a price which should seem enticing.

Instead of advocating the forestation of good farm land, the writer believes that most foresters only advocate forestation of land which is bringing in less than $1 an acre a year. These conditions are not confined to New England. In Michigan and Wisconsin there are still larger areas of sand plain land lying idle since the virgin forests were cut off. Throughout the southern Appalachian region there are innumerable "deadenings" where the timber was killed by girdling; corn or some other crop was raised for a few years and the places abandoned. The average farmer is not such an ignoramus as many writers would indicate; and will usually make as much out of a piece of land as market conditions allow. Now that the public lands have been mostly taken up and there is no longer a surplus of farm production, some of the abandoned land will undoubtedly be farmed again, but much of it is only fit for forest production.

Mr. Beardsley maintains that "forests retard civilization." It is a fact that in regions like Northern Michigan where the forests have been wasted and the land is now non-productive, civilization is retarded. It would be difficult, however, to find a German, or a Frenchman, or a Swiss accustomed to net revenues of from $5 to $12 an acre from the forests, to agree to this statement. It is hard to see how civilization in Vermont would be retarded if 100,000 acres now producing an income of, perhaps, $50,000 were so improved as to produce $300,000.

So far as the writer has observed, the highways winding in and out through the mountains of the Black Forest region are equal to those of our best agricultural communities. Under our past methods of stripping a region of its timber there has been no incentive for building or maintaining good roads, but modern forestry by its very purpose of maintaining a permanent income from the forest requires permanent roads of good grades. In fact road construction has been one of the chief lines of work of the Government in the National forests. If the railroads are to be "seriously injured" by forests it would seem to be a very short sighted policy on the part of the New York Central R. R., the Boston & Albany R. R., the Delaware & Hudson R. R. and the Rutland R. R. to be running an Agricultural and Forestry Special Train through the states of New York, Massachusetts and Vermont and for the Pennsylvania R. R. to maintain a forestry department.

Forest fires have destroyed the growth of immense tracts and some human lives, but forest fires have long since been eliminated in Europe and it is the chief work of the foresters in this country at present to do away with this source of damage. The efforts of the U. S. Forest Service have been so thorough that the percentage of the national forests burned has been reduced as follows:

1904	.66 of 1%
1905	.16 of 1%
1906	.12 of 1%
1907	.07 of 1%

It is very regrettable that there seems to be a disposition on the part of many engineers to oppose the whole forestry movement simply because they believe that forests do not affect stream flow. The importance of the forestry movement is primarily economic and does not rest on the influence of forests on stream flow. The data at hand on this latter question is evidently very insufficient, and in studying the question, let us approach it in a scientific spirit and not with prejudice either for or against the forests.

Yours very truly,

A. F. Hawes,
State Forester.

Burlington, Vt., March 16, 1910.

[We can emphasize the truth of our correspondent's statement. The pasture lands of New England have greatly deteriorated in the past half century. Millions of acres are growing up to ferns, weeds, and worthless bushes and produce only trifling forage for cattle or sheep. Nearly all of these old pasture lands are too rough and steep for profitable cultivation. Similar conditions obtain on the Adirondack plateau and all through the Appalachians. It will take at least a decade and probably two or three to plant with trees these lands which are unfit for agriculture and practically worthless for anything else except forest culture. Until that task is accomplished, no one need worry about the forests encroaching upon the farming lands.—Ed.]

SANDY KNOLL, RICHMOND, VT.
(Only Growth is Sweet Fern, Hardhack and Gray Birch. Should be Planted to Trees.

A LEDGY PASTURE IN STARKSBORO, VT.
(Outcrop of granite. Should be Planted to Trees.)

More Concerning Railway Survey Methods.

Sir: Mr. E. T. Abbott, M. Am. Soc. C. E., whose letter appears in your issue of April 7, is certainly to be credited with some most interesting "discoveries" in methods of railroad location. It is truly refreshing to hear of a man who calculates latitudes and departures for logging roads, when the engineers in charge of location on many of our largest railways still persist in platting the calculated courses from a meridian, and with a protractor at that. It is true that with this latter method they manage to get their locations staked out with comparatively little work, and mostly in the right place; but just think of the joy of using logarithms, and the immense superiority of the results, when they *can* be used, by any possible stretch of the imagination. The results following the use of logarithms are shown by the fact that after the logging road was built, the train stayed on the track; surely a triumph of scientific location.

Then, too, Mr. Abbott never permits the telescope to be transited over and the deflection angle read, it is so much better and avoids error, when the transit is out of adjustment, to read the large angle and subtract it from 180° or 360° or something else, and thus make a little calculation to show the value of a mathematical training rather than read the angle direct.

The method of keeping level notes is also interesting and "novel" and as your correspondent states is not given in the "books" in just that way, though most of us have used something similar, except that columns 4 and 5 are transposed, as it seems more natural to have the rod readings between the H. I. and the elevation.

The method of checking up backsights and foresights is of course as old as the railways and is noted in most of the "books" of any value, some, or at least one, of which goes so far as to suggest that errors may occur in reading the rod and to suggest a method of checking that.

It is truly a delight to find a conscientious railroad locating engineer who gets up in the morning, has breakfast, walks two or three miles to his work, gets started before daylight, and then comes in and works till midnight platting his notes. At some of the recent discussions at the American Society of Civil Engineers' meeting on the proposed legislation to make engineering a closed profession, it was stated that efforts to do this were putting us in line with the labor unions and that the first thing we know we shall be striking for an eight-hour day. I think Mr. Abbott's experience will prove that there are still many conscientious engineers who think that 15 to 20 hours a day are none too many to put in at this work, especially on railroad work where engineering often costs as much as 1½% to 2% of the total cost of the work! Railroad engineers on location get paid at least as much as mechanics and there is no reason why they should not work at least twice as many hours per day for their money, because their efforts are always appreciated.

Very truly yours,

F. Lavis, M. Am. Soc. C. E.

50 Church St., New York, April 7, 1910.

Cooling a Boiler Furnace to Increase Efficiency.

Sir: In an editorial note in your issue of March 17 (p. 315), conclusions are reported from tests made at the University of Illinois using two similar boilers, one fitted with an encircling-tile furnace roof and the other equipped with "T" tiles, which latter leave the lower half of the tubes exposed to the fire. The figures, as given, make it appear that a higher efficiency was secured with the exposed tubes.

I wish to call attention to the fact that the percentage of CO_2 was highest in the tests with the exposed tubes. This was consequently an important factor as affecting the result secured. As extended experience of the writer, and others, with conditions similar to those prevailing in these tests has shown results contrary to the conclusions presented in Bulletin No. 34, of the Engineering Experiment Station of the University of Illinois. In view of the prominence given to the matter and wide circulation it has received, it may be well to say that the conclusions presented should not be accepted without question.

It is unfortunate that much experimental work, undertaken by young and inexperienced men, is given the indorsement it often receives in bulletins issued by various public institutions.

Very truly yours,

A. Bement,
Consulting Engineer.

2114 Fisher Bldg., Chicago, Ill., March 26, 1910.

[The percentages of CO_2 in the eight trials re-

ported in Bulletin 34 are as follows: with the fully protected furnace, 7.5, 5.1, 7.7, 7.0; with the exposed lower tubes, 6.7, 7.7, 7.7, 7.9. The averages would be 6.8% and 7.5% respectively. These figures, which our correspondent claims are the cause and not an effect of the better results obtained by cooling the furnace, clearly support the argument of the Experiment Station Bulletin that a certain amount of cooling of the combustion chamber of boiler furnace can often be secured without impairing the combustion appreciably and, at the same time, materially reducing the radiation and stack losses through having lower temperatures in the furnace and flue gases.—Ed.]

The Civic Services of a College Faculty in a Small City.

Sir: The civic obligation of every citizen as well as the moral obligation of every man to his neighbor is undisputed. The College Professor as a citizen owes a service to the city, the state, the nation. Inasmuch as his endowments are larger, possibly the responsibility is greater than upon other men. But the response to the call, on the part of the members of college faculties, is a matter of note, shown by the illustrations that have appeared in the various periodicals under the discussions of this question. (See Eng. News, p. 134, Feb. 3, 1910, and March 3, 1910.)

The writer is a member of the Faculty of Rutgers College, New Brunswick, N. J., and he has with little effort collected the following list of services, these services being gratuitous in nearly every case, which list he offers as one more among the list of colleges already mentioned.

These services have been rendered during the past ten or fifteen years. The list might be unduly large for an article of this nature should we attempt a longer period, though we must mention in passing the very distinguished services of Dr. George H. Cook, Professor in the College from 1853 to 1889, and of Dr. David Murray, Professor from 1863 to 1876, both of whom were members from New Jersey of a joint commission appointed by the Legislatures of New York and New Jersey, the duty of the commission being to have the boundary line between the two states resurveyed and definitely established. This is but one of a number of services rendered by these men. Mention must also be made of Dr. E. A. Bowser, for more than thirty years Professor of Mathematics and Civil Engineering, who had charge of the U. S. Coast and Geodetic Survey for New Jersey and who was also acting surveyor for the commission to rerun the boundary line between New York and New Jersey. These men are all deceased, Dr. Bowser having died in February.

Beginning with the president of the college, the professors are mentioned in the order in which their names occur in the catalog.

President Demarest is a member of the Cleveland Monument Association, a service in a sense of a national character; he is a member of the Washington's Crossing Commission for the State of New Jersey, a member of the Board of Managers of the New Jersey State Agricultural Experiment Station, a member of the Park Commission for the city of New Brunswick, and also a member of the Play Grounds Committee for the city.

Dr. F. C. Van Dyck, Dean and Professor of Physics and Experimental Mechanics, has been a member of the Board of Health of the city for more than four years.

Dr. Charles E. Hart, Professor Emeritus, is now, and was for a long time before his retirement, a member of the Board of Trustees of the Children's Industrial Home.

Dr. Austin Scott, Professor of History and Political Science, was for several years a member of the Board of Managers of the New Jersey Sanatorium for Tuberculous Diseases.

Dr. Louis Bevier, Jr., Professor of the Greek Language and Literature, was for several years a member of the State Board of Education, is now and has been for many years a member of the State Council of Education, and for five years was Inspector of High Schools for the state, the last service being a salaried one.

Dr. A. A. Titsworth, Professor of Civil Engineering, was for a number of years a member of the Park Commission for the city, directing the survey and plans of the parks; he was acting assistant under Dr. E. A. Bowser in the U. S. Coast and Geodetic Survey for New Jersey; is a member of the Advisory Sewage Disposal Commission for the city; he was one of the commissioners appointed by the Supreme Court of New Jersey to resurvey the boundary lines between Somerset and Morris counties, and between Morris and Hunterdon counties, and was assistant to Dr. Bowser in the resurvey of the boundary line between New York and New Jersey.

Dr. Julius Nelson, Professor of Biology, was for several years a member of the Board of Education of the Highland Park Public Schools.

Dr. J. B. Smith, Professor of Entomology and Entomologist for the State, was a member of the city Board of Health for more than eight years and President of the Board more than half that period. He is consulting Entomologist to the State Board of Forestry and to the State Board of Health. He recently appeared before the Senate and House Committees on Interstate Commerce and Agriculture urging favorable reports on bills regulating the traffic in and composition of insecticides and fungicides, and he is a frequent lecturer before the public on entomological subjects.

Dr. E. B. Voorhees, Professor of Agriculture, Director of the Agricultural College Experiment Station, and Superintendent of the College Farm, is President of the State Board of Agriculture, a member of the State Board of Forestry, a member of the Board of Commissioners of the State Museum, a member of the Board of Managers of the State Agricultural Experiment Station, a member of the Live Stock Commission for New Jersey, and is a member of the Commission on National Resources Conservation.

Prof. R. W. Prentiss, Professor of Mathematics and Astronomy, is a member of the Board of Education of the Highland Park Public Schools, and is Secretary of the Board of Managers of the Well's Memorial Hospital.

Dr. E. L. Stevenson, Professor of History, was a member of the Jamestown Exposition Commission for New Jersey, and has been a member for several years of the Board of Examiners for Teachers' Certificates in the city of New Brunswick, being President of the Board at the present time.

Dr. Wm. I. Chamberlain, recently Professor of Logic and Mental Philosophy, is a member of the Board of Trustees of the Public Library of the city of New Brunswick.

Mr. I. S. Upson, Registrar of the College and Secretary of the Faculty, is Treasurer for the City Public Library and is a member of the Board of Managers of the Children's Industrial Home.

Prof. Cullen W. Parmelee, Professor of Ceramics, has rendered a service to the state geologist in some reports on the peat deposits in New Jersey, and he is rendering an economic service to the city in testing bricks intended for city pavements.

Prof. Myron T. Scudder, Professor of the Science of Teaching, is a member of the Play Grounds Committee for the city.

The writer was at one time secretary of a local organization of the Anti-Saloon League.

Dr. J. G. Lipman, Associate Professor of Agriculture, is a frequent lecturer in the schools of the state upon agricultural subjects, relating especially to problems in rural districts.

The college professor is looked upon as a specialist in his chosen field. But while he may exalt his labors and researches above other things, I would venture the assertion that every college in the land can cite its list of professors who have not ignored the call to a public service. This service may sometimes have been with pay, not usually commensurate with the service, however, but more often without compensation save an honest satisfaction and the approval of a few.

Richard Morris,
Professor of Mathematics and Graphics,
Rutgers College.

New Brunswick, N. J., March 23, 1910.

[Our correspondent's general position is well taken, but he goes somewhat further afield than we intended when we raised certain questions in our issue of Feb. 3, 1910, in connection with a typhoid epidemic in a small college town in Missouri. What we had in mind was not so much service on town and state boards by individuals, as influence brought to bear upon civic problems by college faculties, both as individuals and collectively; the collective influence not being due so much to concerted action as to the spirit and general influence of a body of men of culture, many of whom have special knowledge and experience which qualifies them for civic leadership. For instance, where engineering and medical schools form part of the university located in a small town one might expect that a continuous campaign of education would be waged against any and every local unsanitary condition, and particularly for pure water and pure milk and for an efficient local board of health. But, as we pointed out in our issue of March 3, there have been some notable instances to the contrary—or else campaigns were ineffective.

Another possible line of activity on the part of college professors has to do with improvements in the framework of local governments. Several members of the faculty of the University of California, including President Benjamin Ide Wheeler, took a hand in framing the interesting city charter now in force there (see Eng. News, March 25, 1909), and within the past few months Prof. Lewis J. Johnson, M. Am. Soc. C. E., of Harvard University, together with some of his fellow professors, has drafted a proposed new charter for Cambridge, Mass.—Ed.]

The Raldiris Bill Requiring a State License for Civil Engineers Practicing in New York.

Sir: At a hearing held March 24, 1910, before the Committee on Public Education to consider the bill for licensing engineers there were present, the President of the American Society of Civil Engineers, Mr. Bensel, Mr. Alfred Noble, Prof. Burr of Columbia University, Mr. Walter G. Elliot, President of the American Technical League, Deputy State Engineer H. W. DeGraff, Mr. W. R. Davis, Secretary of the Society of Engineers of Eastern New York, as well as other engineers interested in the bill.

I proposed to the chairman of the committee that as a discussion of the different sections of the bill would entail some time, it would be better if the gentlemen at the hearing would consent to express their approval or disapproval of the principles contained in the bill. The Secretary of the New York Civil Service Association, with counsel, were the only ones opposed.

The other gentlemen present had objections to make to different sections of the bill and in order to be able to arrive at some amicable agreement I suggested that all representatives confer and prepare a bill which, in the opinion of the majority of the conferees, would be to the best interests of the engineering profession in the State of New York. They unanimously agreed that this was the best course to pursue and the hearing was adjourned with the agreement on my part that I would not further press the bill introduced by me, but would at some future time present as a substitute the new bill thus drawn.

Trusting that this course will meet with your approval and that as a result of our efforts we may be able to present a bill that would meet with the approval of the engineering profession, I remain,

Very truly yours,
Edward J. L. Raldiris.

Assembly Chamber, Albany, April 1, 1910.

The Height of Bridges Over the Allegheny River.

Sir: I note in your issue of March 31 (p. 377), comments on the relation of the War Department to bridges over navigable streams, with special reference to the discussion respecting the raising of the bridges across the Allegheny River in the vicinity of Pittsburg, Pa.

Practically all of the highway bridges built across the Allegheny River, Monongahela River and Ohio River in this section of Pennsylvania are, and were originally, toll-bridges, some of which have been made free through process of law. In all cases it has been, and is, necessary to obtain a charter from the Commonwealth, if the bridge be wholly within one state, or, as in the case of the bridges down the Ohio River, a charter from one or the other of the adjoining Commonwealths, with the preference given to West Virginia charters, if they can be obtained.

In this Commonwealth the method of procedure has been to obtain the necessary charter, complete the organization of the company, and if the bridge was across the Monongahela River an act of Congress has to be obtained; if across the Allegheny River no act of Congress was necessary, and if across the Ohio River the Ohio River Bridge Law, passed in 1872 and amended in 1883, covers the conditions that have to be fulfilled for all bridges across that stream.

Up to the year 1896 the approval of the Pittsburg Coal Exchange, which represented solely the river navigation interests, was all that was necessary. In the summer of 1896 Major Hoxie, who was then in charge of the United States Engineer office, at Pittsburg, ruled on the application of the Bessemer & Lake Erie R. R. (Carnegie interests), from Pittsburg to the Lakes, that thereafter the Government engineers would hold a public hearing, free to the river interests and all others concerned, at which an open discussion would be held, and the case decided according to the facts. This method of conducting hearings is still closely adhered to in applications for bridges over both the Allegheny and Monongahela Rivers. For all bridges across the Ohio River a board of three Government engineers sit at the hearing instead of one.

The lower portion of the Monongahela, for a distance of 75 miles from Pittsburg, is seldom a dangerous river to erect bridges across, either winter or summer; but all the leading bridge companies have been for many years aware that the Allegheny River is perhaps the most dangerous river to erect bridges across between the Allegheny and the Rocky Mountains, barring perhaps the Missouri. This is due to the sudden rise of the river, which formerly carried enormous quantities of drift in summer floods, and is always liable in winter to gorges of ice and their resultant effects.

In 1889-90 I took the contract from the firm of C. J. Schultz & Co. to remove the old wooden Burr truss

bridge across the Allegheny River at Ninth St. and erect the present steel structure. On the morning of May 24, 1890, my foreman, Clem. McMann, had given orders to run the traveler out onto the channel span to begin erection of the present steel superstructure, when he noticed a derelict coal-boat bottom loaded with about 300,000 ft. of lumber, passing through the Ft. Wayne bridge, a few hundred feet upstream. This barge struck the first three bents of the trestle adjoining the channel pier on the Pittsburg side with such force that practically all the bracing of the heavy trestle was weakened, and orders were given to tie up the traveler and await developments. I was on the bridge inside of half an hour, possibly about 7.30.

Before beginning erection I had done what I always did when preparing for the erection of any important structure, and gone into the history of the stream, learning that from 1806 to 1889 there had been but three floods in the month of May in the Allegheny River, all of them under 18 ft. We had then had two floods in the month of May, both of them over 18 ft., and as there was 16 ft. 6 ins. of water at the time of the accident and rising, it was decided about ten or eleven o'clock to order Charlie Hook out with his little steamboat with ropes to raft as much of the trestle as possible, as it was then believed a rise in the river would carry out the falsework. The stage of the river about the time the "Charlie Hook" was ordered out was probably 18 ft. He had been in my employ exclusively to do what little towing was necessary in the erection of this bridge and especially in case he might be needed for an emergency. I instructed my foreman to order him out as above mentioned, and his reply was: "No damn fool of a pilot would navigate the Allegheny River in a flood."

It is unnecessary to say he was paid for his services and dismissed. These remarks are made with no reflection on Charlie Hook, who is still living and a capable, active pilot on the rivers. He owned his own boat and was protecting his own property in an intelligent, sensible way. His remarks were true then and are true to-day.

Ten years ago the Monongahela River Coal & Coke Co. formed a trust and bought out all the mine owners, and to-day gives employment to perhaps 90% of the pilots in this vicinity. There is practically no such thing as individual ownership, neither is that personal identity, such as Charlie Hook exercised, in evidence any longer.

The height of the channel span as erected by me was approved by the Pittsburg Coal Exchange, still in existence. Two or three years after the erection of the Ninth St. bridge Theodore Cooper designed and superintended the erection of the present Sixth St. bridge across the Allegheny River. The location of the piers, length of span and the clearance were approved by the Pittsburg Coal Exchange.

Eight years ago the question of raising these bridges was taken up during the regime of Major Sibert. A thoroughly competent and well known civil engineer, a man thoroughly conversant with bridge construction, was retained by the Government and made plans to be adopted and followed out in the raising of bridges across the Allegheny River, showing the location and length of the channel span. These plans were, of course, approved by the Government and they were hailed with joy by the Pittsburg Coal Exchange.

This spring, when the same engineer brought before the War Department a set of plans for the proposed new bridge across the Allegheny River at the Point (the junction of the Monongahela and Allegheny Rivers to form the Ohio River), he was naturally surprised to find that the river interests, which are still represented by the Pittsburg Coal Exchange, opposed his plans, which were an exact duplicate of those he had made eight years ago. This opposition was acquiesced in by the representative of the United States located at Pittsburg, and the plans had to be changed to meet the ideas of the Coal Exchange, notwithstanding it meant the introduction of a grade at each approach of practically 5%, besides compelling the city to spend a large sum of money that would otherwise have been unnecessary.

It is not surprising to any one thoroughly acquainted with the facts that the Pittsburg Coal Exchange should reverse itself; but it is very disappointing from the ethical side of the questions at issue to know and feel that the Government engineers should allow themselves to be impressed to the extent that they have been with the arguments put forward by the navigation interests.

It is an established fact that navigation in this vicinity is on the decline. On May 25, 1890, the day the trestle was washed out, the Allegheny River was literally filled with derelict rafts of lumber. To-day you can count on the fingers of one hand the number of such rafts coming down the river annually. In fact, I have not seen a single raft in recent years. There is no navigation down the Allegheny River at the present time, and it is very, very questionable if there ever will be, as the center of gravity of trade is now leading direct from Pittsburg down the Ohio River, west, and it is no longer going up even the Monongahela River, which furnishes the best navigation facilities of any river in this section of the country, if not in the United States. If the figures are correct that have been given me by the bridge people, by the railroad people and others, the tonnage over the Allegheny River bridges compared with the tonnage under them is as a thousand to one.

On Jan. 6, 1910, the Commissioners of Venango County came to Pittsburg to study the condition of travel over the bridges in order that they might with greater intelligence decide on the style of bridge to build at Oil City, across the Allegheny River. For half an hour we stood on the Smithfield St. bridge and watched the travel on both roadways in a heavy snow storm. Although there was but one or two inches of snow on the bridge floor at that time, there was a continuous blockade of heavily loaded teams. The cause of the blockade was the horses slipping on the smooth, wooden paving blocks on the 2% grade. What will be the condition of travel over the Allegheny River bridges if the contentions of the river interests are approved by the War Department, and the grade of 5% is adopted on both approaches of practically every bridge across the Allegheny River?

Respectfully yours,

Edwin K. Morse.

Commonwealth Bldg., Pittsburg, Pa., April 1, 1910.

[We have commented on the questions raised by this letter in our editorial columns.—Ed.]

Notes and Queries.

It's an ill wind that blows nobody any good. "R. F.," New York City, writes us that the approach of Halley's comet is being exploited by the advertising men of an Oklahoma hail insurance company as follows:

MAY 18, EARTH PASSES THROUGH TAIL OF COMET.

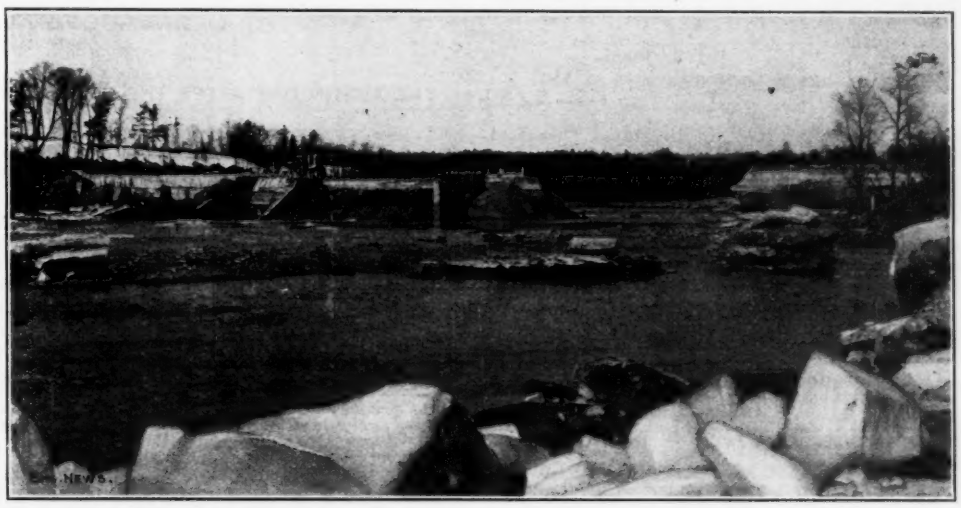
There is no need to fear that loss of life will result as a direct consequence, as only the extreme end of the comet will come in contact with the earth and it is composed of rarefied gases, but the very contact of these gases with the atmosphere will produce extraordinary weather conditions, so astronomers say, and it is predicted that in all likelihood hail will do great damage to crops everywhere. The farmer who wants to play safe this year will take out a big policy of hail insurance.

Through an inadvertence the article on p. 392 of our issue of last week, entitled "The Use of Hypochlorite of Lime to Disinfect the Water-Supply of Montreal," was not credited to its author, Mr. James O. Meadows, Sanitary Engineer, Provincial Board of Health, 9 Rue St. Jacques, Montreal, P. Q.

Failure of an Earth Dam with Concrete Core Wall at Erindale, Ontario.

By FRANCIS F. LONGLEY,* Assoc. M. Am. Soc. C. E.

The Credit River, in the southern part of the Province of Ontario, Canada, flows southward into Lake Ontario about fifteen miles west of Toronto, and drains an area of some 450 square miles. In the last few miles of its course it has a considerable fall, sufficient to warrant the construction of works at the village of Erindale for the development of electric power for use in the towns west of the city of Toronto. This development is at present in the hands of The Erindale Power Co., although it was started by another company. The works are to consist in general of the dam which is the subject of this article, forming a pond of some 125 acres in extent; a tunnel 900 ft. long leading the water to the forebay; and a power house of three wheels. The low water flow of the stream is about 140 ft. per sec. and the total fall made available by the dam and the power tunnel is about 65 ft. The power plant is designed for the development of 900 HP. Construction work is moderately well advanced, the tunnel having been completed and the powerhouse being nearly ready for the installation of the machinery.



DAM OF ERINDALE POWER CO., ON CREDIT RIVER, ONTARIO. FAILED DURING CONSTRUCTION.

Construction work on the dam was commenced over four years ago, but was discontinued before much progress had been made. Work was resumed upon it last summer and carried on continuously up to the time of the break. The dam is an earthen dam with a concrete core wall. The latter is about 18 ins. wide at the top and 5 ft. wide at the bottom, and is carried down through the soft overlying shale and gravel in the river bed to a hard argillaceous sandstone. The height of the core wall at the point of deepest excavation is about 35 ft., and the earth embankment was to have been carried some 15 ft. higher. The dam has an overall length of about 700 ft. with a spillway section of massive concrete in the middle and sluiceways immediately adjoining this.

The scheme for the construction of the dam was apparently as follows: to build the spillway and sluiceways complete, and the dam from there to one of the abutments up to a height which would not be overtopped by a flood going over the spillway; the other end of the dam meanwhile being left down for the passage of the stream; the gap to be closed and the dam at that end to be completed up to a safe height with the stream flowing through the sluiceways. This procedure involved the risk that during the completion of this last portion a flood, which would exceed the capacity of the comparatively small sluiceways, might come along unexpectedly, and that in consequence the unfinished dam might be destroyed. This seems to be exactly what occurred.

Early in March just passed, work on the dam had reached a stage where the gap was to be closed. The flow was diverted through the sluiceways, the core wall was built up and the earth embankment partly placed. The sluiceways safely carried the ordinary flow of the stream, the total width of 21 ft., discharging a depth of 5 to 6 ft. of water. Before the closure was made secure, however, a freshet came along, exceeding the capacity of the sluiceways and backing the water up against the new work. The earth embankment had been partly completed on the upstream side of the core wall, but on the downstream side parts of the wall had no support whatever. Some of the concrete in the core wall had been in place only three or four days. The pressure of the rising water was too great for the structure to resist under these conditions and at about seven o'clock on the morning of March 7, with scarcely any warning, a section gave way and let the flood through. This first break, which occurred at a point where the concrete was green and the fill very inadequate, was quickly followed by further fail-

*Resident Engineer, Filtration Plant, Toronto, Ont.

ure due to the scour of the flood and the ice, until about 100 ft. of the dam was down.

At the time of failure the water came to within about 5 ft. of the top of the core wall. It did not reach the spillway level at all, so there was no relief from the flood except at the inadequate sluiceways. Rainfall records for Toronto show 0.16-in. precipitation the day before the failure and almost none other during the week preceding. A snowfall for February of 24.2 ins., which is considerably above the average for that month, together with thawing weather for the week preceding the failure, of course helped to produce high water. The opinion seemed general, however, that the flood that caused the failure was not excessive.

The cause of the failure was clearly the inability of the light and partly-set and insufficiently supported core wall to resist the pressure of the unexpected flood. It should serve to emphasize the necessity for ample provision for flood flow during construction of such works.

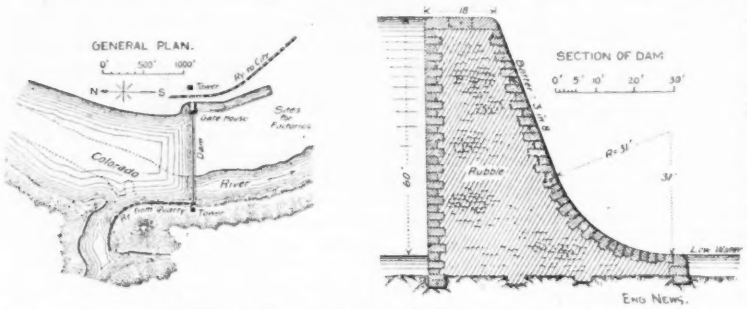


FIG. 1. ORIGINAL DESIGN OF COLORADO RIVER DAM, AUSTIN, TEXAS.
(From Engineering News of July 11, 1891.)

When the dam went out, the pond was full of floating ice which did a good deal of damage. It tore away practically all of one wing wall extending upstream from the spillway, and scoured the gap made by the break, concrete core wall and all, right down to rock foundation. The cost of the failure will be considerable, and it will delay the delivery of power to consumers. No one was injured by the accident, athough a shack occupied by a number of Italians was struck by the flood and destroyed.

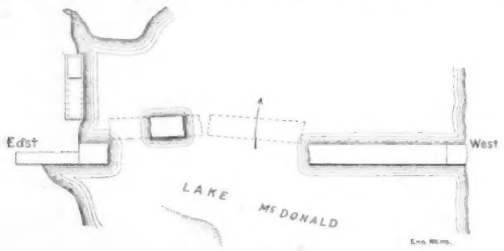
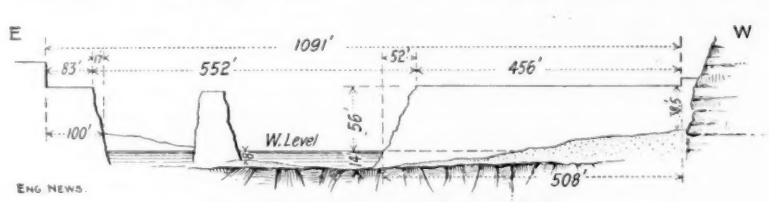


Fig. 3. Plan.
(From Engineering News of April 19, 1900.)



The Vertical Scale equals twice the Horizontal Scale.

Fig. 4. Elevation Looking Down-Stream, as Measured June 9, 1900.
(From Engineering News of June 21, 1900.)

FIGS. 3 AND 4. THE AUSTIN DAM AFTER THE FAILURE OF APRIL 7, 1900.

Designs and Contract for Rebuilding the Colorado River Dam at Austin, Texas.

Just ten years ago (April 7, 1900), the 60-ft. masonry dam of the city of Austin, Tex., across the Colorado River, failed under an 11-ft. flood-flow over the crest. A length of some 500 ft. of the dam slid out bodily. The powerhouse just below the dam at its east end was partly wrecked and seven men were killed in it. Since the failure no work has been done on the dam, although repeatedly steps were taken toward planning its rebuilding.

On April 5, 1910, the city voted in a special election to contract with the Dumont-Holmes Steel Concrete Co. for reconstructing the dam by building a hollow concrete dam in the gap left by the failure, and installing wasteway sluices and powerhouse machinery in the interior of the new section. Full details of the contract had been worked out prior to the election, between the Business League of Austin, the City Council, and J. C. Dumont of Detroit, Mich., who had been engaged in building a dam at Marble Falls, Tex., about 70 miles above Austin on the Colorado River.

The Business League began negotiations with Dumont several months ago. After many meetings between the two parties, a form of ordinance embracing a contract was agreed upon, and this was submitted to the City Council, together with Dumont's specifications and plans for the work, with the request that an election be called to obtain the approval or disapproval of the citizens. The Council ordered an election for April 5, 1910. The result was a vote of 2,187 in favor, and 38 against, and the city officials thereupon signed the contract.

Previous History*

The Austin dam has had a checkered history. Its various phases will be found recorded in the pages of Engineering News from 1890 to 1900, and a concise summary up to the time of failure was given in the issue of April 12, 1900, p. 244. A brief review of the history will explain the present situation.

In 1890 the city of Austin undertook to build an overfall dam across the Colorado River (of Texas) at a point about 3 mi. above the city, for a water and electric supply system. A reservoir and a filter were part of the system, as was also a powerhouse at the dam, with pumps and electric generators. J. P. Frizell and John Bogart reported on the proposed dam in March, 1890, and Mr. Frizell afterward prepared plans and took charge of the construction as Chief Engineer to the city. Bernard Corrigan of Kansas City, Mo., was the contractor.

When the work was about half built, there was friction between the city officials and the engineers, which brought about special reports from E. Geyelin of Philadelphia, Pa., and J. T. Fanning of Minneapolis, Minn., and in June, 1892, Mr. Frizell resigned. The shape of the dam was changed by rounding the top in consequence of Mr. Fanning's report [see Fig. 1, showing Frizell's section, and Fig. 2, Fanning's section], and the location and arrangement of the powerhouse were also changed. The situation led to some acrimonious discussion both on matters of design and on the professional aspects of the relations between the engineers. After Mr. Frizell's departure, however, the friction between the city officials and the engineers continued, and often the engineers' instructions were directly countermanded by the Board of Public Works. On May 2, 1893, the last stone of the dam was laid. Just four weeks later a leak developed at the penstock bulkhead, the bulkhead cracking badly. Repairs had to be done at the cost of about $100,000. In the early stages of the repair work the engineer who succeeded Mr. Frizell, E. W. Groves, resigned because of continued interference by the city officials. The repairs were completed after much trouble, but the leak was left discharging through a 10-in. pipe from a closed drain chamber or sump.

The plant was now put in operation, with no material interruption till the break in 1900. But throughout the six years there were indications that undesired actions were going on. The 10-in. drain pipe showed increased flow. Erosion took place under the toe of the dam, and at one time a man fishing pushed his rod 8 ft. under the toe. In 1899 several sink-holes were discovered behind the dam, which had to be filled by dumping clay and in one case by cofferdamming. In December, 1899, settlement of the earth around the penstocks just below the bulkhead occurred; on excavating, it was found that two penstocks had settled and buckled, due to washing by a stream from a broken 3-in. penstock drain pipe. This defect also was repaired, and the subsequent failure was not caused by it. But the earlier leaks and the undercutting were symptoms of a progressive erosion and washing of the foundation, which soon proved disastrous. It is an important fact that the underlying rock is badly faulted and of poor quality on a part of the length of the dam.

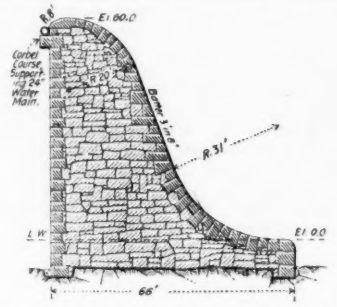


Fig. 2. Cross-Section of Austin Dam as Built.
(From Engineering News of Aug. 29, 1894.)

Prior to 1900 the dam had passed floods rising to nearly 10 ft. over the crest. The Colorado has a drainage area of about 40,000 sq. mi. above the dam. The water carried much silt, moreover, and this deposited in the basin at so rapid a rate that by the beginning of 1900 the storage capacity of the 1,800-acre basin was reduced about one-half. There were drain pipes at the west end of the dam, but they had never been used since the dam was finished.

On April 6-7, 1900, a flood due to heavy rains raised the level of the basin behind the dam to such a point that on the morning of the 7th water was flowing over the crest 11 ft. deep. At 11 a. m. the dam failed near the center, and a section about 500 ft. long was pushed out hori-

*The previous history may be found in the following references, of which those marked with an asterisk are illustrated:

Descriptive articles:
July 11, 1891, p. 24*; Aug. 18, 1892, p. 152* (Fanning's report); Sept. 29, 1892, p. 303* (Frizell's discussion); Jan. 26, 1893, p. 87* (construction methods); July 27, 1893, p. 78*; Jan. 25, 1894, p. 75; Aug. 2, 1894, p. 89*; Feb. 22, 1900, p. 135* (silt deposit and leaks); April 12 and 19, 1900, pp. 244* and 250* (failure); May 10, 1900, p. 308*; June 21, 1900, p. 412*; June 28, 1900, p. 428*; July 26, 1900, p. 64; Dec. 6, 1900, p. 390*; May 30, 1901, p. 392*; April 3, 1902, p. 272, and Nov. 12, 1908, p. 530* (estimates for rebuilding).

News Notes:
June 8, 1893, p. 545; June 29, 1893, p. 618; Sept. 28, 1893, p. 260; Oct. 19, 1893, p. 305; April 26, 1900, p. 265; June 14, 1900, p. 385; Jan. 30, 1902, p. 92.

Letters:
Jan. 12, 1893, p. 38*; Feb. 23, 1893, p. 182; March 8, 1900, p. 161; March 15, 1900, p. 179; March 29, 1900, p. 212 (containing Babson's report to bondholders); April 19, 1900, p. 259; April 26, 1900, p. 274; May 3, 1900, p. 290*; June 21, 1900, p. 410; Sept. 5, 1901, p. 160; Sept. 26, 1901, p. 218; April 24, 1902, p. 333.

Editorial comment:
Nov. 10, 1892, p. 444; Dec. 15, 1892, p. 564; Jan. 12, 1893, p. 36; Jan 26, 1893, p. 84; Aug. 3, 1893, p. 94; June 14, 1894, p. 485; Feb. 22, 1900, p. 128.

zontally, and then disintegrated, a short piece being left standing at a point about a hundred feet downstream, and several feet below its original level. Eight persons in the powerhouse were drowned by water backed in through the windows. Later in the day the powerhouse was wrecked, being undermined by the escaping waters.

FIG. 5. VIEW OF AUSTIN DAM BREAK, FROM HEADGATES, ABOUT ONE HOUR AFTER THE FAILURE OF APRIL 7, 1900.
(From Engineering News of June 21, 1900.)

Figs. 3, 4, 5 and 6 herewith, reproduced from former issues of Engineering News, portray the effects of the failure. The flood did no great damage below, fortunately. Soundings taken in the gap in the dam subsequently proved that none of the foundation masonry was left, and that the rock was gone for a depth of several feet below the dam.

The dam and powerhouse with machinery cost about $750,000. The damage done was estimated at $250,000.

Present Contract.

The following is a summary of the terms of the contract:

1. The company (Dumont-Holmes Steel Concrete Co.) is to have the right to erect, maintain and operate a hydro-electric plant and to overflow certain lands.

2. The company is to have the use of the old dam, powerhouse, salvage of same, lines and poles from dam to city during the life of the contract (20 years after completion).

3. The company may assign the contract.

4. The company guarantees the city against damages caused by breaking of dam, in addition to the repair agreement under (8), but only to the amount of all instalment-payments not due at time of break.

5. The company is to furnish a dam 65 ft. high above "low water" or "normal water" (an elevation not otherwise defined or known; very indefinite); three turbines of 1,000 HP. and two of 500 HP.; three electric generators of 1,000 HP. and one of 750 HP.; a reservoir of 6,000,000 gals. capacity; a filter of capacity 1,000,000 gals. per day; a pumping plant of two pumps, each of capacity 6,000,000 gals. per day, against a head of 315 ft. above low water (or 250 ft. above crest of new dam).

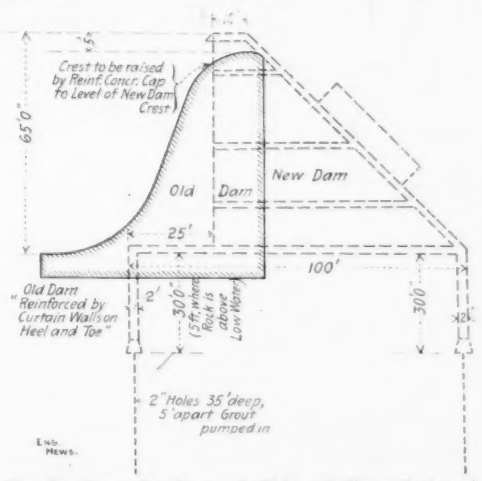

Crest to be raised by Reinf. Concr. Cap to Level of New Dam Crest
65'0"
Old Dam
New Dam
25'
100'
2'
30'0"
(5 ft. where Rock is above Low Water)
30'0"
"Old Dam Reinforced by Curtain Walls on Heel and Toe"
2" Holes 35' deep, 5' apart Grout pumped in
Eng. News.

Fig. 7. Cross-Sections of Old and New Parts of Austin Dam as Proposed Under Rebuilding Contract.

6. The company is to begin work within 90 days from final passage of the ordinance and to complete dam and machinery ready for operation within two years.

7. The company deposits $10,000 to credit of Mayor to be forfeited to city if it fails to carry out its agreement.

8. If dam is destroyed, or if leaks, seepage or other wastes of water occur affecting natural flow for power purposes, payment shall cease till repairs are made.

9. The company agrees to furnish the full amount of 3,000 HP. so long as the lake level is not more than 5 ft. below the crest, provided the inflow at the head of the lake exceeds 220 sec.-ft.; and a minimum of 1,000 HP.

10. At no time shall the company draw the lake level lower than 25 ft. below crest of dam. When the flow will not furnish 1,000 HP. the company is to furnish steam power to make up the deficiency, or may purchase the deficiency power from the city's steam plant at the minimum rate.

11. The city agrees to pay 40 semi-annual payments of $25,000 each, the first to be paid six months after official notice of completion of dam and starting of plant. Payments are to be made from earnings of plant and no taxes are to be levied for this purpose.

12. The city shall own and control the lake and shall have exclusive use of all power from it, except 25 HP. reserved for lighting and power at the dam.

13. Dam and plant shall be the property of the city after the contract has expired.

14. For inspecting the construction work, the city shall appoint an engineer agreeable to the contractor or his assigns.

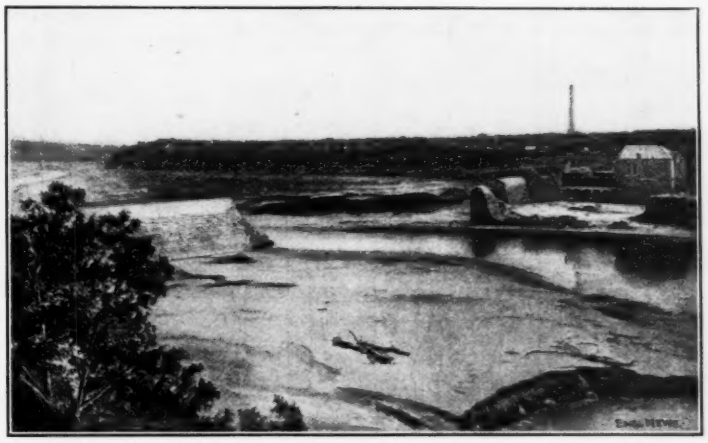


FIG. 6. VIEW OF AUSTIN DAM IN JUNE, 1900, LOOKING NORTHEAST FROM WEST BANK BELOW DAM.
(From Engineering News of June 28, 1900.)

(The sandbar in the foreground was deposited by the floodwaters after the break. The remains of the silt accumulation in the basin behind the dam are visible in the picture. The powerhouse was on the far bank, just below the dam. In the new hollow concrete dam, the powerhouse is to be in the dam at the near or west end of the break.

Dam and Powerhouse.

The new dam, filling the breach made by the failure in 1900, is to be of reinforced concrete, of hollow triangular section, with upstream

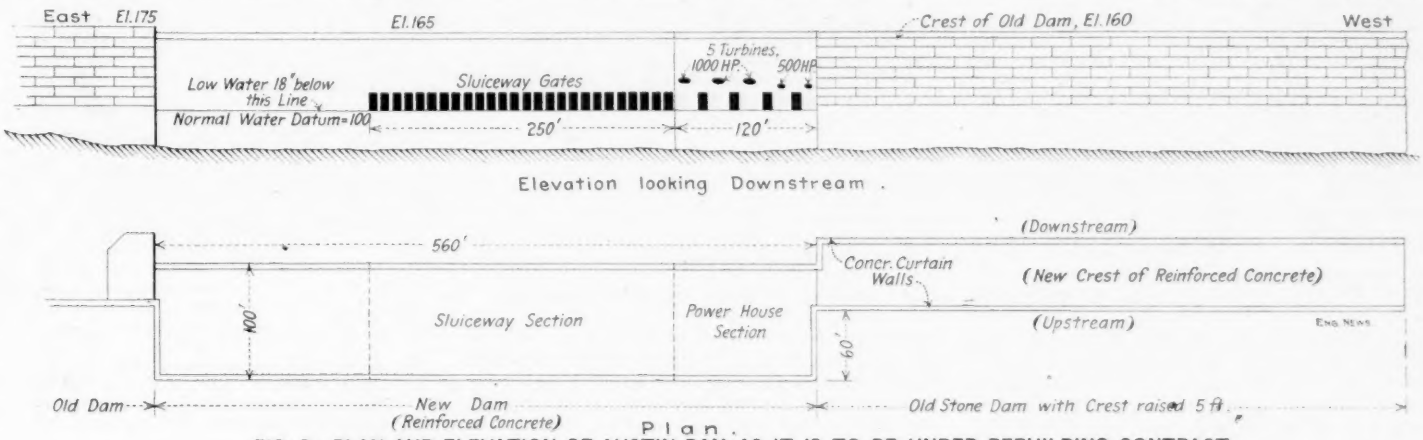


FIG. 8. PLAN AND ELEVATION OF AUSTIN DAM AS IT IS TO BE UNDER REBUILDING CONTRACT.

face sloping 45° and downstream face vertical. It is shown by Fig. 7 (this sketch is not part of the contract plans), the full lines representing the old dam and the dotted lines the new dam.

Including a 25-ft. apron on the downstream side, the base of the new dam will be 100 ft. wide; the height of crest will be 65 ft. above normal water, or 5 ft. above the crest of the old dam. At heel and toe there is to be a curtain wall 2 ft. thick going down 30 ft. (except where rock is above low water, at which points the toe wall need be only 5 ft. deep). In the bottom of the curtain-wall trench 2-in. holes are to be drilled, 5 ft. apart, to a depth of 35 ft., and liquid cement grout is to be pumped into these holes under a maximum pressure of 150 lbs. per sq. in.

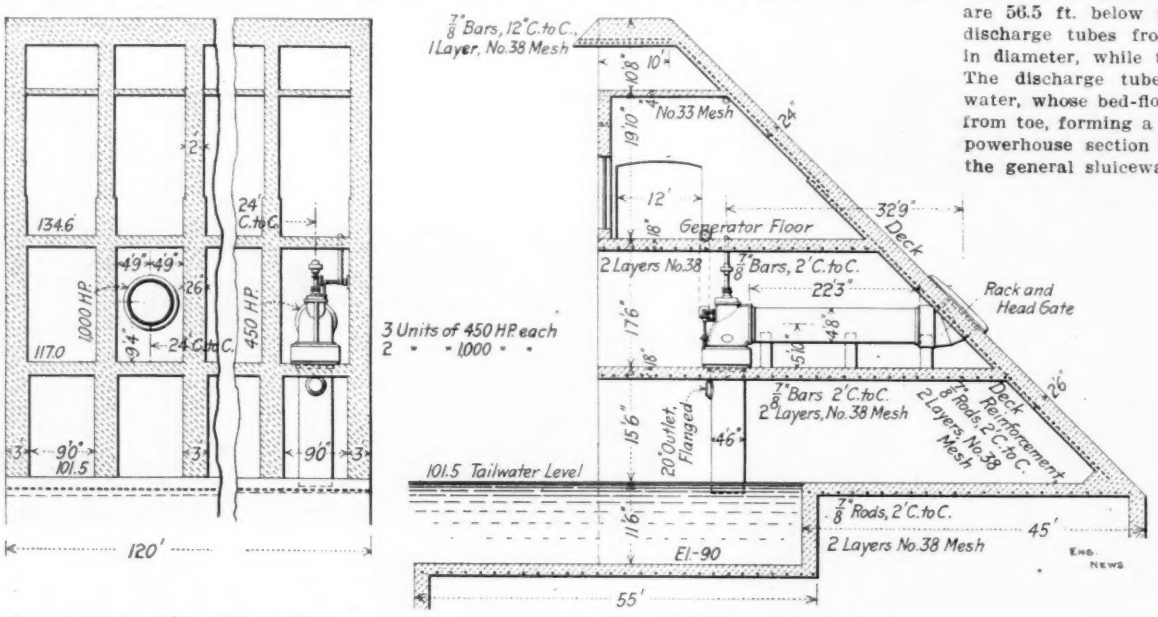


FIG. 9. SECTIONS OF POWERHOUSE PART OF NEW AUSTIN DAM.

controlled by sliding gates on the upstream face of the dam, which gates are to be operated by hydraulic cylinders placed in chambers projecting above the face of the dam.

The powerhouse is formed by a 120-ft. length of the new dam adjoining the west portion of the old dam. In this length the buttress walls are spaced 12 ft. on centers, so that the wheel and dynamo chambers will be about 9½ ft. wide. The inlet pipes enter from the inclined face of the dam. The discharge from the turbines is vertically downward into a tailrace

clear heights of the stories are as follows: sluiceway story, 14 ft.; turbine story, 17.5 ft.; generator story, 19.5 ft.; attic story, 6 ft. There are ten sluiceways in the powerhouse, whose clear dimensions are 9 × 14 ft. and whose centers are 56.5 ft. below the crest of the dam. The discharge tubes from the turbines are 54 ins. in diameter, while the supply pipes are 56 ins. The discharge tubes project into the tailrace water, whose bed-floor drops off at a point 45 ft. from toe, forming a shoulder 11.5 ft.; thus in the powerhouse section the apron is 11.5 ft. below the general sluiceway floors.

The sluiceway section of the dam, Fig. 10, has its buttress walls spaced 10 ft. c. to c. Vertically it has five stories, separated by one floor and several groups of tie-beams. The lower story serves the purpose of sluiceway and the central that of operating gallery for the gates.

A few extracts from the specifications (which to a great extent complete and amplify the drawings) may be quoted here.

FOUNDATIONS.—The entire dam is placed upon and anchored to the uncovered rock ledge, and for additional security against sliding the up and down stream ends are footed in trenches excavated out of the rock ledge.

* * *

The heel wall shall be 2 ft. wide and to extend 30 ft. below low water mark or elevation 100. At bottom of trenches a 2-in. hole will be drilled every 5 ft. centers and 35 ft. deep, and in that hole liquid grout composed of 3 parts of sand and 1 part of cement will be pumped under pressure and when gage shows pressure of 150 lbs. the operation will be terminated. The contractor reserves the rights, in case of large cavities, to dig down to same and stop flow of water by any other practicable manner (using steel sheet pilings or compressed air caissons).

The toe wall in front of apron shall go down 30 ft. below low water line 100, except in places where rock is above water line, said toe wall shall go 5 ft. in rock below low water line.

The trenches for buttress walls shall be 2 ft. in the rock and anchors shall be placed every 5 ft., going down in rock 3 ft. The anchors are pieces of reinforcing metal; they are set in the drilled holes and the hole itself is filled with grout.

* * *

The base walls [3 ft. 6 ins. thick.—Ed.] are erected on the lines of the base anchors and five other anchors are set in the top of the base walls for the anchorage of the superimposed lower sluice walls; all anchors are pieces of reinforcing metal.

* * *

A base fill of convenient pieces of rock, or gravel, all interstices being filled with sand, is deposited in the entire space between the base walls. This fill is intended to form a compact mass and is to be deposited in layers not exceeding 18 ins. in depth and before the next layer is placed upon it the sand is to be washed into all the voids between the stones.

Weep-holes are to be left in the heel wall so that the surplus water in the base fill can escape (this being the direction in which the surface rock slopes downward); after the base fill is completed the weep-holes in the heel wall are to be closed with grout.

* * *

The lower floor is constructed upon the base walls. . . . Base walls for apron are to be 18 ins. thick. The floor is connected with the base walls by means of anchors which are set in the top of the latter and

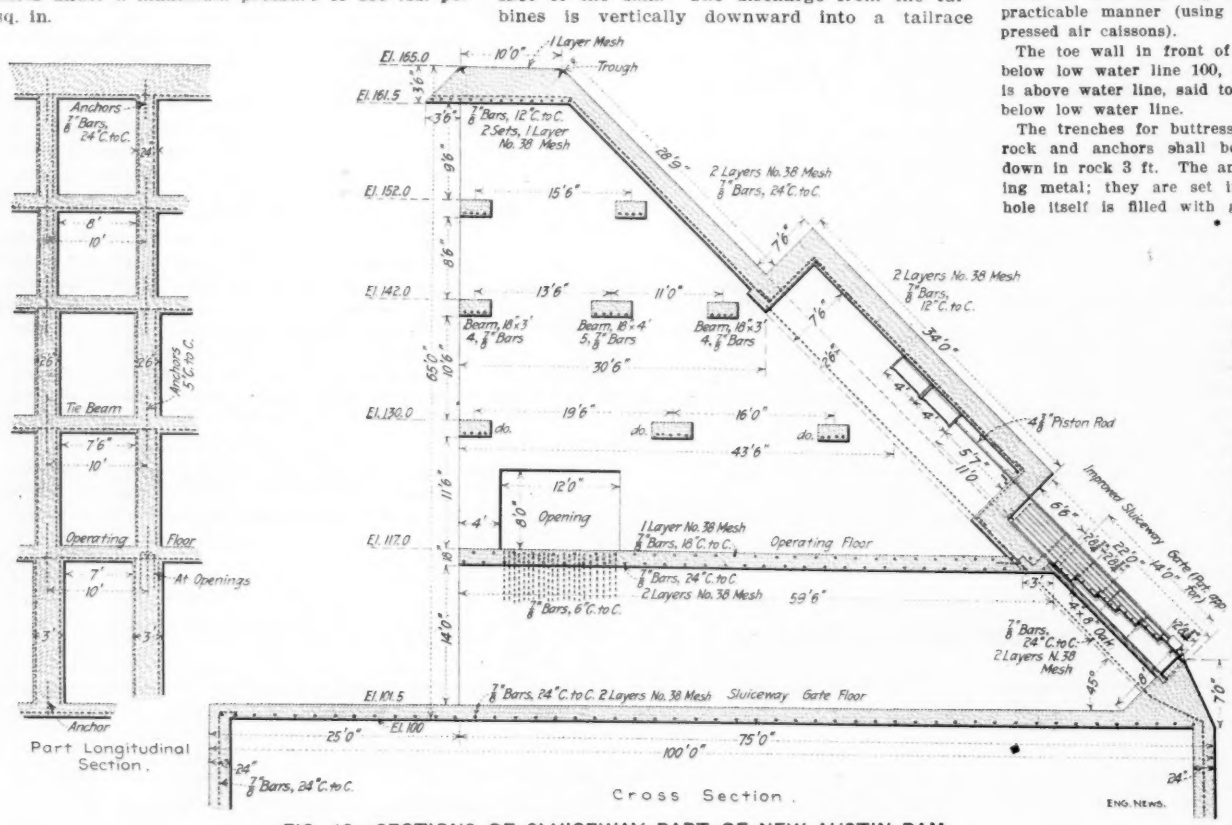

El. 165.0
El. 161.5
El. 152.0
El. 142.0
El. 130.0
El. 117.0
El. 101.5
El. 100
1 Layer Mesh
Trough
7/8" Bars, 12" C. to C., 2 Sets, 1 Layer No. 38 Mesh
2 Layers No. 38 Mesh, 7/8" Bars, 24" C. to C.
Beam, 18"×3', 4, 7/8" Bars
Beam, 18"×4', 5, 7/8" Bars
Beam, 18"×3', 4, 7/8" Bars
do.
Opening
1 Layer No. 38 Mesh, 7/8" Bars, 18" C. to C.
Operating Floor
7/8" Bars, 24" C. to C., 2 Layers No. 38 Mesh
7/8" Bars, 6" C. to C.
2 Layers No. 38 Mesh, 7/8" Bars, 24" C. to C.
4 7/8" Piston Rod
Improved Sluiceway Gate (Pat. App. for)
7/8" Bars, 24" C. to C., 2 Layers No. 38 Mesh
7/8" Bars, 24" C. to C. 2 Layers No. 38 Mesh Sluiceway Gate Floor
Anchors, 7/8" Bars, 24" C. to C.
Tie Beam
Anchors, 5' C. to C.
Operating Floor
At Openings
Anchor
Part Longitudinal Section.
Cross Section.
ENG. NEWS.

FIG. 10. SECTIONS OF SLUICEWAY PART OF NEW AUSTIN DAM.

The old portions of the dam are to have the crest raised 5 ft. by building on the masonry a cap section exactly similar to the corresponding part of the new dam. Also, curtain or cut-off walls are to be built at heel and toe, of the filling the space between buttress walls. Counting the crest and bed-rock floor there are five horizontal floors, namely, the bed-rock or sluiceway floor, the turbine floor, the generator floor, and the roof or attic floor and the crest. The

rise 1 ft. above this floor in order to give anchorage connection to the superimposed lower sluice walls. . . . A channel is left about 12 ins. wide and 6 ins. deep in which the vertical reinforcing rods of the upper wall are set and in which the superimposed wall finds a footing. The sides and bottom of this channel are to be left as rough as possible.

WATER FACE WALL.—The bulkheads are constructed of XX concrete [6:27.—Ed.] 24 ins. thick with perpendicular reinforcing rods placed 2 ins. from their downstream faces, 24 ins. centers, and 2 layers of No. 38 American Wire and Steel reinforcing.

CREST.—The spillway is constructed upon the upper sluice walls, being 3 ft. 6 ins. thick. . . . ; its upper edges are 9 ft. long sections of a steel trough channel anchored in the concrete by bolts. . . . The spillway is constructed of XX concrete with reinforcing rods placed 2 ins. from its bottom face.

CUT-OFF WALLS FOR OLD DAM. . . . Heel and toe walls in all cases go down same depth as in sluiceway dam.

CREST ADDITION TO OLD DAM.—The top or addition to be placed on top of western spillway is to be 65 ft. above low water level, and is to be constructed as follows: Buttresses 18 in. thick, placed 12 ft. centers . . . , the crest of dam to be same thickness and shape as balance of dam, the bulkhead to be 18 ins. thick, reinforced with ¾-in. rods perpendicular, 2 ft. centers, and covered with one thickness of No. 38 American Wire and Steel fabric.

SLUICE GATES.—The gates are not described in the specifications except as to number (30). The operating cylinders are specified as 12 ins. bore.

Two plunger force pumps shall be furnished to operate the cylinders.

It is specified that should any acceptable and superior method of gates be offered, that the same may be used.

EMERGENCY GATES are required to remove the water pressure from the sluice-gates in order to approach the latter for examination and repair. Emergency gates, not shown in plans, are platforms constructed by dimension timbers with a minimum thickness of 8 ins. and 16 ft. by 10 ft. in dimensions, the timbers being placed with the shortest span and bound and held together securely. These timber platforms may be lowered along the upstream faces of the walls and of the bulkheads until they completely cover the entrance to the respective sluice where the gate is to be examined for repairs. The emergency gate may be conveyed to the point to be lowered by being suspended from two cranes on the platform of a hand car running on a track laid on the spillway of the sluice dam and chained to spillway anchors when in position. After the emergency gate completely covers the sluice gate entrance the sluice gate may be opened, the water drained off and the sluice chamber entered.

Reservoir and Filter.

The reservoir and filter are completely covered in the following paragraph of the specifications. The filter is described only by the requirement that it must deliver water *pure as present supply.*

There shall be built and equipped one complete reinforced concrete reservoir, to be of 6,000,000 gals. capacity, and a suitable filter capable of delivering 1,000,000 gals of water in 24 hrs., to deliver same pure as present supply. Said filter shall have direct connection to reservoir. The reservoir shall be 200 ft. by 500 ft., and 8 ft. deep, inside dimensions, and shall be divided into five compartments of 100 ft. by 200 ft. each or such other dimensions, showing equal capacity, as will be suitable to site selected. Reservoir shall have 24-in. standard cast-iron outlet from each compartment.

The filter shall be built so that the bottom of the same shall be at least 2 ft. above the top of the reservoir or as may be naturally agreed upon.

The reservoir and filter shall be built on land furnished by the City of Austin on the west side of the river, at a location at an altitude of 300 ft. above low water. The excavation for foundation on site shall not exceed an average of 3 ft. in depth.

Materials.

The materials to be used in the work are the following:

Concrete made of cement and granite gravel from Marble Falls, this being described as carrying enough sand to be satisfactory without further sand addition; in two mixtures.

X = 4 bags cement per cu. yd., to be used in all works below low water, in aprons, corewalls, foundations of machinery, reservoir and filter plant.

XX = 6 bags cement per cu. yd., to be used in all other parts of the work. The main part of the dam superstructure apparently is to be built of this richer mixture.

Man-size stone may be used in walls, aprons and spillway above low water, and in all work below low water except toe and heel walls.

The cement is specified: "Must be able to stand standard specifications from U. S., and should be aged cement if possible."

Reinforcing metal is to be either plain or twisted rods, and triangle-mesh fabric of the American Steel & Wire Co.

Specifications for Plain and Reinforced Concrete and Steel Reinforcement.*

CONCRETE MATERIALS.—1. The cement shall be Portland and shall meet the requirements of the standard specifications.

2. Fine aggregate shall consist of sand, crushed stone, or gravel screenings graded from fine to coarse, and passing when dry a screen having ¼-in. diameter holes. It shall be preferably of siliceous material, clean, coarse, free from vegetable loam or other deleterious matter, and not more than 6% shall pass a sieve having 100 meshes per lin. in.

3. Mortars composed of 1 part Portland cement and 3 parts fine aggregate by weight when made into briquettes shall show a tensile strength of at least equal to the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand.

4. Coarse aggregate shall consist of crushed stone or gravel, graded in size, and which is retained on a screen having ¼-in. diameter holes. It shall be clean, hard, durable and free from all deleterious material. Aggregates containing soft, flat or elongated particles shall not be used.

5. The water used in mixing concrete shall be free from oil, acid, and injurious amounts of alkalies or vegetable matter.

STEEL REINFORCEMENT.—6. Steel shall be made by the open-hearth process. Rerolled material will not be accepted.

7. Plates and shapes used for reinforcement shall be of structural steel only. Bars and wire may be of structural steel or high carbon steel.

8. The chemical and physical properties shall conform to the following limits:

Elements Considered.		Structural steel %.	High carbon steel,%.
Phosphorus, max..	Basic	0.04	0.04
	Acid	0.06	0.06
Sulphur, maximum.....		0.05	0.05
Ult. tensile strength, lbs. per sq. in.....		60,000	88,000
Elong., min. % in 8 ins., Fig. 1.....		1,500,000* Ult. ten. str'gth	1,000,000 Ult. ten. str'gth
Character of fracture....		Silky	Silky or finely granular
Cold bends without fracture		180° flat†	180° $d = 4t$†‡

*See paragraph 15.
†See paragraphs 16 and 17.
‡"$d = 4t$" signifies "around a pin whose diameter is four times the thickness of the specimen."

9. The yield point for bars and wire, as indicated by the drop of the beam, shall be not less than 60% of the ultimate tensile strength.

10. If the ultimate strength varies more than 4,000 lbs. for structural steel or 6,000 lbs. for high carbon steel, a retest shall be made on the same gage, which, to be acceptable, shall be within 5,000 lbs. for structural steel, or 8,000 lbs. for high carbon steel, of the desired ultimate.

11. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the railway company, in which case an excess of 25% above the required limits will be allowed.

12. Specimens for tensile and bending tests for plates and shapes shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled or with both edges parallel; or they may be turned to a diameter of ¾-in. with enlarged ends.

13. Bars shall be tested in their finished form.

14. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing ⅜-in. and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

15. For material less than 5/16-in. and more than ¾-in. in thickness the following modifications will be allowed in the requirements for elongation: (A) For each 1/16-in. in thickness below 5/16-in. a deduction of 2½ will be allowed from the specified percentage. (B) for each ⅛-in. in thickness above ¾-in., a deduction of 1 will be allowed from the specified percentage.

16. Bending tests may be made by pressure or by blows. Shapes and bars less than 1-in. thick shall bend as called for in paragraph 8.

17. Test specimens 1 in. thick and over shall bend cold 180° around a pin, the diameter of which, for structural steel, is twice the thickness of the specimen, and for high carbon steel, is six times the thickness of the specimen, without fracture on the outside of the bend.

18. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workmanlike finish.

19. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it, except that bar steel and other small parts may be bundled with the above marks on an attached metal tag.

20. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected and shall be replaced by the manufacturer at his own cost.

21. All reinforcing steel shall be free from excessive rust, loose scale, or other coatings of any character, which would reduce or destroy the bond.

WORKMANSHIP.—22. The unit of measure shall be the cubic foot. A bag containing not less than 94 lbs. of cement shall be assumed as 1 cu. ft. of cement. Fine and coarse aggregates shall be measured separately as loosely thrown into the measuring receptacle.

23. The fine and coarse aggregates shall be used in such relative proportions as will insure maximum density.

24. The proportions of materials for the different classes of concrete shall be as follows.*

25. For plain concrete, a proportion of 1:9 (unless otherwise specified) shall be used; one part of cement to a total of nine parts of fine and coarse aggregates measured separately (for example, 1 cement, 3 fine aggregate, 6 coarse aggregate).

26. For reinforced concrete a proportion of 1:6 (unless otherwise specified) shall be used; one part of cement to a total of six parts of fine and coarse aggregates measured separately.

27. The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing shall continue until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

28. The various ingredients, including the water, shall be measured separately, and the methods of measurement shall be such as to secure the proper proportions at all times.

29. A machine mixer, preferably of the batch type, shall be used, wherever the volume of the work will justify the expense of installing the plant. The requirements demanded are that the product delivered shall be of the specified proportions and consistency and thoroughly mixed.

30. When it is necessary to mix by hand, the mixing shall be on a watertight platform of sufficient size to accommodate men and materials for the progressive and rapid mixing of at least two batches of concrete at the same time. Batches shall not exceed ½-cu. yd. each. The mixing shall be done as follows: The fine aggregate shall be spread evenly upon the platform, then the cement upon the fine aggregates, and these mixed thoroughly until of an even color. The water necessary to mix a thin mortar shall then be added and the mortar spread again. The coarse aggregates, which, if dry, shall first be thoroughly wetted down, shall then be added to the mortar. The mass shall then be turned with shovels or hoes until thoroughly mixed and all of the aggregate covered with mortar. Or, at the option of the engineer, the coarse aggregate may be added before, instead of after, adding the water.

31. The materials shall be mixed wet enough to produce a concrete of such consistency that it will flow into the forms and about the metal reinforcement, and which, on the other hand, can be conveyed from the place of mixing to the forms without separation of the coarse aggregate from the mortar.

32. Retempering mortar or concrete (*i. e.*, remixing with water after it has partially set) will not be permitted.

33. Concrete after the addition of water to the mix shall be handled rapidly from the place of mixing to the place of final deposit, and under no circumstances shall concrete be used that has partially set before final placing.

34. The concrete shall be deposited in such a manner as will prevent the separation of the ingredients and permit the most thorough compacting. It shall be compacted by working with a straight shovel or slicing tool kept moving up and down until all the ingredients have settled in their proper place and the surplus water is forced to the surface. In general, except in arch work, all concrete must be deposited in horizontal layers of uniform thickness throughout.

35. In depositing concrete under water, special care shall be exercised to prevent the cement from floating away, and to prevent the formation of laitance.

36. Before depositing concrete in forms, the forms shall be thoroughly wetted except in freezing weather, and the space to be occupied by the concrete cleared of debris.

*Presented with the report of the Committee on Masonry at the annual meeting of the American Railway Engineering and Maintenance of Way Association at Chicago, March 15, 17. Adopted as recommended practice.

*This blank to be filled for each contract.

37. Before placing new concrete on or against concrete which has set, the surface of the latter shall be roughened, thoroughly cleansed of foreign material and laitance, drenched and slushed with a mortar consisting of 1 part Portland cement and not more than 2 parts fine aggregate.

38. The faces of concrete exposed to premature drying shall be kept wet for a period of at least three days.

39. The concrete shall not be mixed or deposited at a freezing temperature, unless special precautions, approved by the engineer, are taken to avoid the use of materials containing frost or covered with ice crystals, and to provide means to prevent the concrete from freezing.

40. Where the concrete is to be deposited in massive

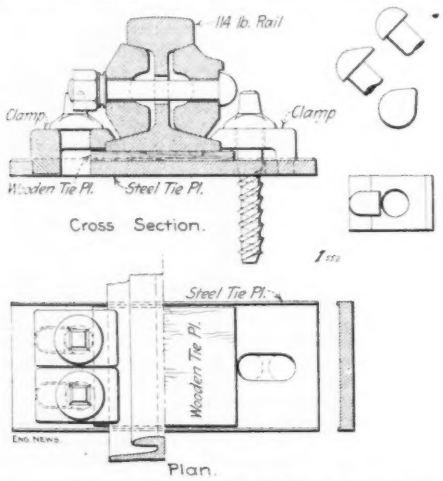


Fig. 1. Track With 114-lb. Rails on the Belgian State Railways.

work, clean, large stones, evenly distributed, thoroughly bedded and entirely surrounded by concrete, may be used, at the option of the engineer.

41. Forms shall be substantial and unyielding and built so that the concrete shall conform to the designed dimensions and contours, and so constructed as to prevent the leakage of mortar.

42. The forms shall not be removed until authorized by the engineer.

43. For all important work, the lumber for face work shall be dressed to a uniform thickness and width; shall be sound and free from loose knots and secured to the studding of uprights in horizontal lines.

44. For backings and other rough work undressed lumber may be used.

45. Where corners of the masonry and other projections liable to injury occur, suitable moldings shall be placed in the angles of the forms to round or bevel them off.

46. Lumber once used in forms shall be cleaned before being used again.

DETAILS OF CONSTRUCTION.—47. Wherever it is necessary to splice the reinforcement otherwise than as shown on the plans, the character of the splice shall be decided by the engineer on the basis of the safe bond stress and the stress in the reinforcement at the point of splice. Splices shall not be made at points of maximum stress.

48. Concrete structures, wherever possible, shall be cast at one operation, but when this is not possible, the resulting joint shall be formed where it will least impair the strength and appearance of the structure.

49. Girders and slabs shall not be constructed over freshly formed walls or columns without permitting a period of at least four hours to elapse to provide for settlement or shrinkage in the supports. Before resuming work, the tops of such walls or columns shall be cleaned of foreign matter and laitance.

50. A triangular-shaped groove shall be formed at the surface of the concrete at vertical joints in walls and abutments.

51. Except where a special surface finish is required, a spade or special tool shall always be worked between the concrete and the form to force back the coarse aggregates and produce a mortar face.

52. Top surface shall generally be "struck" with a straight edge or "floated" after the coarse aggregates have been forced below the surface.

53. Where a "sidewalk finish" is called for on the plans, it shall be made by spreading a layer of 1:2 mortar at least ¾-in. thick, troweling the same to a smooth surface. This finishing coat shall be put on before the concrete has taken its initial set.

Recommended Practice for Designing Reinforced-Concrete Structures.

(1) The materials and workmanship for reinforced concrete should meet the requirements of the foregoing specifications for plain and reinforced concrete.

The concrete recommended for general use is a mixture of 1 part of cement to 6 parts of fine and coarse aggregate. A richer mixture will be found advantageous for special conditions.

(2) The dead load is to include the estimated weight of the structure and all other fixed loads and forces acting upon the structure.

(3) The live load is to include all variable and moving loads or forces acting upon the structure in any direction.

(4) As the working stresses herein recommended are for static loads, the dynamic effect of moving loads is to be added to the live load stresses.*

(5) The span length for beams and slabs is to be taken as the distance from center to center of the supports, but not to exceed the clear span plus the depth of beam or slab.

(6) The internal stresses are to be calculated upon the basis of the following assumptions:

(a) A plane section before bending remains plane after bending.

(b) The distribution of compressive stresses in members subject to bending is rectilinear.

(c) The ratio of the moduli of elasticity of steel and concrete is 15.

(d) The tensile stresses in the concrete are neglected in calculating the moment of resistance of beams.

(e) The initial stress in the reinforcement due to contraction or expansion in the concrete is neglected.

(f) The depth of a beam is the distance from the compressive face to the centroid of the tension reinforcement.

(g) The effective depth of a beam at any section is the distance from the centroid of the compressive stresses to the centroid of the tension reinforcement.

(h) The maximum shearing unit stress in beams is the total shear at the section divided by the product of the width of the section and the effective depth at the section considered. This maximum shearing unit stress is to be used in place of the diagonal tension stress in calculations for web stresses.

(i) The bond unit stress is equal to the vertical shear divided by the product of the total perimeter of the reinforcement in the tension side of the beam and the effective depth at the section considered.

(k) In concrete columns the concrete to a depth of 1½

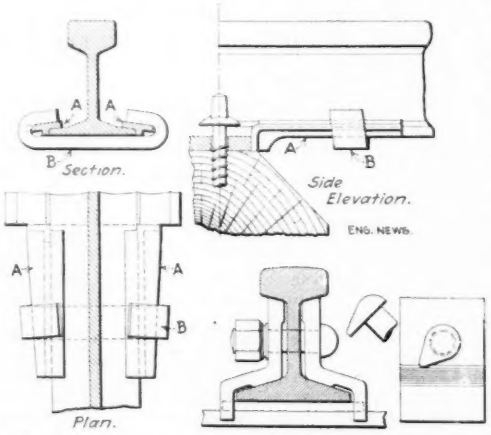


Fig. 2. Devices to Prevent Creeping of Rails.

ins. is to be considered as a protective covering and is not to be included in the effective section.

(7)† When the maximum shearing stresses exceed the value allowed for the concrete alone, web reinforcement must be provided to aid in carrying the diagonal tension stresses. This web reinforcement may consist of bent bars, or inclined or vertical members, attached to or looped about the horizontal reinforcement. Where inclined members are used, the connection to the horizontal reinforcement shall be such as to insure against slip.

In the calculation of web reinforcement when the concrete alone is insufficient to take the diagonal tension the concrete may be counted upon as carrying one-third of the shear. The remainder is to be provided for by means of metal reinforcement consisting of bent bars or stirrups, but preferably both. The requisite amount of such reinforcement may be estimated on the assumption that the entire shear on a section, less the amount assumed to be carried by the concrete, is carried by the reinforcement in a length of beam equal to its dpth.

(8) The following recommended working stresses, in pounds per square inch of section, are for use in concrete of such quality as to be capable of developing an average compressive strength of at least 2,000 lbs. per sq. in. when tested in cylinders 8 ins. diameter and 16 ins. long and 28 days old, under laboratory conditions of manufacture and storage, the mixture being of the same consistency as is used in the field:

Structural steel in tension	14,000
High carbon steel in tension	17,000
Steel in compression, 15 times the compressive stress in the surrounding concrete.	
Concrete in bearing where the surface is at least twice the loaded area	700
Concrete in direct compression, without reinforcement on lengths not exceeding six times the least width	450
Concrete in direct compression with not less than 1% nor over 4% longitudinal reinforcement on lengths not exceeding twelve times the least width	450
Concrete in compression, on extreme fiber in cross bending	750
Concrete in shear, uncombined with tension or compression in the concrete	120
Concrete in shear, where the shearing stress is used as the measure of web stress	40
Note.—The limit of shearing stresses in the concrete, even when thoroughly reinforced for shear and diagonal tension, should not exceed.	120
Bond for plain bars	80
Bond for drawn wire	40
Bond for deformed bars, depending upon form	100-150

*The following formula is not recommended by the committee, but is merely given as an illustration:

$$\text{Impact} = \frac{L}{L + D} L$$

L = Live load stress. D = Dead load stress.

†The recommendations regarding web stresses are quoted from a report of the Joint Committee on Concrete and Reinforced Concrete.

Track Construction with 114-lb. Rails; Belgian State Railways.

The Belgian State Railways have rails of four principal sections, weighing 76, 82, 104 and 114 lbs. per yd. The first 114-lb. rails (5,000 tons) were laid in 1907, and have given such good results that they will gradually replace the 104-lb. rails on the busy main lines. The increase in weight of locomotives and cars, and the increase in speed and number of trains, led the engineers to desire a stiffer and more substantial track construction in order to reduce the work and expense of maintenance, to reduce the liability of danger, and to make an easy-riding track for fast trains.

The 114-lb. rail is 6.4 ins. high, 5.4 ins. wide on the base, and the head is 3.2 ins. wide. The web is thin, 0.6-in., as compared with 0.72 in. for the 104-lb. rail. The base or flange is heavy, and the fishing surfaces of head and base have an inclination of 1 in 4. The rail is made in lengths of 59 ft., 39.36 ft. and 29.52 ft. The 59-ft. rail has 27 ties, including both joint ties of the three tie-joints. The tie spacing is 20.8 ins. c. to c. for the three joint ties, 24 ins. between the joint and shoulder ties, and 30 ins. for the intermediate ties. As the rails are laid with broken joints they have the five closely spaced ties at the middle as well as at the ends.

The ties are of wood, protected by ¾-in. steel tie-plates 14.4x6 ins. The tie-plate has low ribs on the long sides to hold in place a wooden bearing plate ½-in. thick. The rail is secured to each tie by three screw spikes with clamps, the front end of each clamp resting on the rail base while the rear end fits into a slotted hole in the tie-plate. In the 104-lb. rails the screw spikes bear upon the rail flange and a rib on the tie-plate. But in practice the wear of the rail base and plate was greater than that of the rib, so that after a time the spike head could not be screwed down to come in contact with the rail base.

The screw spikes for the 114-lb. rails are much longer than those for the other rails, on account of the greater depth of the rail attachments. The older spikes are 5 ins. long under the head and 0.96-in. diameter in the shank. The new design is 6¼ ins. long under the head, with a shank 1.2 ins. diameter, and the shank is 1.84 ins. long on account of the depth of the clamp fastenings. The mushroom head is 2.4 ins. diameter, with the usual square projection on top to receive the socket wrench. The pitch of the thread is 0.6-in.

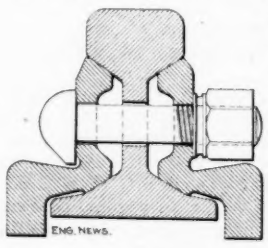


Fig. 3. Experimental Form of Splice Bar.

At the middle of each rail the five closely spaced ties (supporting the joint of the opposite rail) are fitted with anti-creeping devices, shown in Fig. 2. These are pairs of short angle bars with the flange bent down vertically below the rail base. The ends of these vertical portions bearing against the tie-plates. Each pair of creeping plates is held by a 1-in. bolt. This arrangement has the objection of numerous holes in the rail, and experiments are being made with the Paulus anti-creeper, also shown in Fig. 2. Two stops (A) which fit on the rail base and against the tie-plate are held in place by a clamp (B) which passes under the rail and has its ends bent over to hold the stops. The sides of the stops are inclined, and the clamp is driven on until it has a tight grip.

The rail joints are of peculiar design. All the other rails have suspended joints and angle splice bars, and the bars for the 104-lb. rails have wide and heavy flanges which rest on the ties and are held by screw spikes. Under heavy traffic these angle bars break frequently at the joint (generally at the top), and these fractures are considered due to the play between the splice bar and the rail. A special design of splice bar is being tried, in which the upper part is light, and the lower part made very heavy. This is the design of one of the engineers, Mr. Menart, and is shown in Fig. 3. For the supported (three-tie) joints of the 114-lb. rails, however, very heavy plain splice bars are used as shown in Fig. 1. These bars are 3.28 ft. long, with six 1.08-in. bolts. The bolts have oval or kite shaped heads, the longer end engaging with a rib on the splice bar to prevent them from turning. The spacing of the bolts is 6.4 ins.

The particulars given above are taken from a paper in the October number of the "Revue Generale des Chemins de Fer," by Mr. Pierre Decamps, Engineer of the Belgian State Railways. The track construction with 114-lb. rails was designed by Mr. Lambert, Inspector-General, and Mr. Van Bogaert, Chief Engineer.

A Commercial Fuel-Briquette Plant.*

By W. H. BLAUVELT,† M. Am. Inst. M. E.

The subject of fuel-briquetting has attracted much attention on the part of engineers and investors for the past 15 or 20 years, and especially in recent years, during which a number of plants have been built, with more or less commercial and technical success. Our technical literature contains numerous descriptions of certain processes, and discussions of the industry in general. For a history of the development of the art in the United States, and for descriptions of many of the processes which have been tried, reference may be made to the files of our "Transactions," and, for more recent information, to a paper by C. T. Malcolmson, read before the first annual convention of the International Railway Fuel Association in June, 1909.

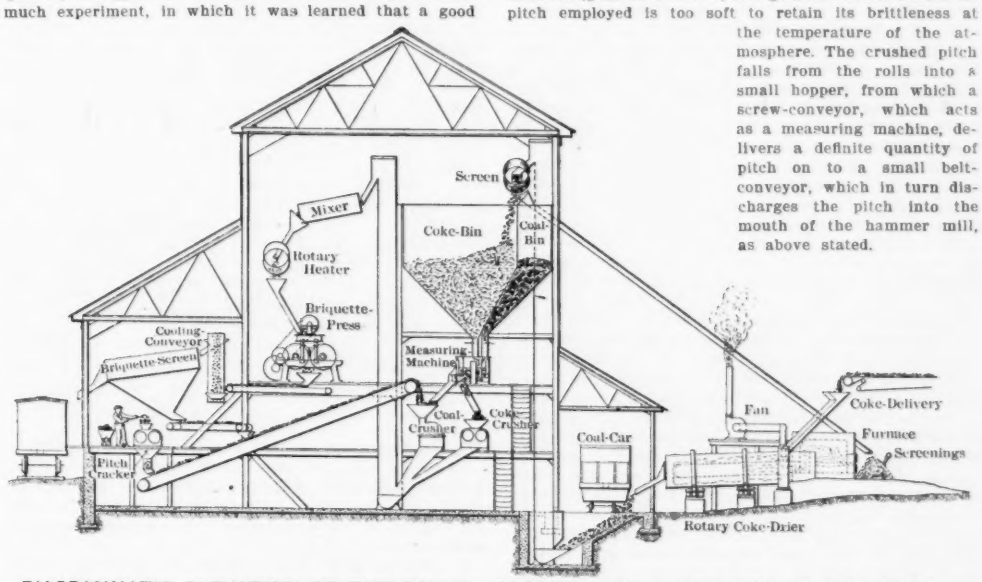
The purpose of the present paper is to describe the briquette-plant of the Solvay Process Co. and the Semet-Solvay Co. at Detroit, Mich., which, after a period of long and costly evolution, is now operating satisfactorily on a commercial basis. I believe that it will be of interest to give the details of operation, power-consumption, labor, etc., as worked out on a practical and commercial scale in a going concern.

The briquette industry has had a somewhat checkered career in the United States, and much the larger portion of the failures has been due entirely to commercial causes. It seems axiomatic to say that before undertaking the installation of a plant for manufacturing briquettes it is necessary that the local situation should be carefully examined: First, to determine the kind of briquettes, if any, the local market will consume; that is to say, whether the available fuel-supply is such that briquettes would be a welcome addition, and whether the most promising field is the industrial or the domestic market. Second, if there is an available supply of raw material, as coal, coke, pitch, etc., which can be worked up into briquettes that will meet the market conditions, and can be obtained at a price that will leave a margin for cost of manufacturing and a suitable profit. If this preliminary investigation does not result satisfactorily, the manufacturer should carry his plans to another place. Although these requirements are axioms of ordinary business prudence, yet neglect to observe them has been the cause of the failure of many undertakings, resulting often in the loss of the entire capital invested.

The next step is the selection of the process of manufacture best adapted to the materials at hand and the quality of briquettes to be produced. A number of different processes and briquetting presses have been developed, both in Europe and in the United States. In Continental Europe the manufacture of briquettes has reached large proportions, and has become an important industry. The usual shape of the European briquettes is that of a rectangular block with rounded edges, weighing from 10 to 0.5 kg., or less. The larger sizes, which are usually broken up before firing, have the advantage of greater convenience in storing. For household purposes the housewife patiently breaks up the large briquettes with a hammer, but not having been accustomed to prepared sizes of anthracite, the annoyance, dirt, and waste caused thereby are not realized. The smaller briquettes, usually of the eggette form, are largely used, specially in Belgium and parts of France.

There is a sharp line in manufacturing between the eggette and other forms. The eggettes are made on rotary presses, the coal and binder being pressed between the faces of two broad wheels or rolls, having faces which are cupped out to receive and compress the briquettes into form. Generally speaking, it is not practicable on these rotary presses to produce briquettes larger than about 6 oz. in weight. On the other hand, the capacity of the reciprocating presses, which are used in making the larger briquettes, falls off rapidly as the size decreases, and it is usually not commercially economical on these presses to make briquettes which weigh much less than 1 lb. each. Some forms of press have been developed, notably in the United States, which, in a measure, combine the features of the rotary and reciprocating presses, and which would produce briquettes of intermediate size between the European rotary and the reciprocating press. These machines, however, have not been fully developed to commercial success.

In planning for the Detroit plant, the domestic market appeared the most promising, and therefore a rotary type of press was selected which would produce small briquettes, or eggettes, each of about 2 oz. weight. After much experiment, in which it was learned that a good many things must not be done and that a few points were absolutely essential to the success of the operation, the plant was developed as it now stands.



DIAGRAMMATIC ELEVATION OF THE SOLVAY PROCESS AND SEMET-SOLVAY COS'. FUEL BRIQUETTING PLANT AT DETROIT, MICH.

The raw materials used are coke-breeze from an adjacent coke-oven plant, and dry non-caking coal from either the Hocking Valley or the Jackson Hill districts. These materials are used in equal proportions, by weight, mixed with from 8 to 9% of the binder. Coke-breeze appears to require somewhat more binder than coal; perhaps on account of its porosity, which allows the binder to be absorbed into the cell structure without useful effect. Probably further experience will result in reducing the percentage of binder used. Coal-tar pitch was selected as the binder, since experience has shown that, broadly speaking, it is the only thoroughly successful binder, generally obtainable at a moderate cost, which can produce a waterproof briquette.

Two processes are in general use, one using soft pitch, the other hard pitch. In the former the pitch is melted by steam-heat or in an oven fired with coal or other fuel, and mixed with the solid fuel while liquid, while in the latter process the pitch is made hard enough to permit of its being ground to a fine powder. In practice this latter means that, adopting the usual tar-distiller's test, the pitch should be somewhat harder than can be chewed in the mouth without fracture after the pitch has been permitted to reach the temperature of the mouth. Unfortunately, no more scientific method of testing the hardness of pitch has been agreed upon as yet. The whole subject is in a rather chaotic stage, so the old tar-distiller's chewing-test is still largely employed.

The hard-pitch method was selected for the Detroit plant, partly because the soft-pitch methods are always a source of danger from fire, but mainly because it is believed that the hard-pitch method is the one which should be developed, with a view to obtaining the pitch at the lowest price delivered at the briquette plant. Hard pitch is more easily transported, either in very cheap packages, or, in cold weather, in bulk, and it can be produced at lower cost, since a larger portion of the more valuable oils contained in the original tar have been removed. Possibly the hard-pitch method requires a slightly larger quantity of binder with some coals, but the lower cost at which it can be manufactured more than offsets this objection, and it also has the advantage of producing less smoke in combustion.

Description of Process.

The accompanying diagram shows the arrangement of the different parts of the plant.

The process as at present conducted is essentially as follows: The coal is unloaded into a track hopper and elevated to the coal-bin. As slack coal is always used, no preliminary crushing is necessary. The coke-breeze usually contains considerable moisture, so in order to maintain constant conditions the breeze is dried in a rotary drier before being elevated to its storage-bin. The coal and coke are brought together from the bins into a measuring-machine, which delivers the two materials in any desired proportion to a hammer-mill of the Jeffrey or Williams type, in which the mixture is finely ground. The pitch which meets the coal and coke in this mill is brought from the pitch-storage shed by a pitchman, who breaks it into pieces of convenient size for feeding to the pitch-cracker. This cracker consists of a pair of rolls, 16 ins. in diameter with 12-in. face, which have small V-shaped corrugations, and are run at a speed of 85 r. p. m. These rolls crush the pitch to about ⅜-in. in diameter, and give no trouble unless the pitch employed is too soft to retain its brittleness at the temperature of the atmosphere. The crushed pitch falls from the rolls into a small hopper, from which a screw-conveyor, which acts as a measuring machine, delivers a definite quantity of pitch on to a small belt-conveyor, which in turn discharges the pitch into the mouth of the hammer mill, as above stated.

By grinding the coal, coke and pitch all together in the hammer mill the three materials are thoroughly mixed, and opportunity is given for each particle of the coal and coke to receive a coating of pitch powder, which, of course, is the theoretical condition to be striven for. Practice has shown that in pulverizing coke-breeze the wear on the hammers of the mill is too great, and it is planned to install a small pair of chilled-iron rolls for pulverizing the coke, leaving the hammer mill for the coal and pitch. The pulverized coke, coal and pitch will be delivered direct to an elevator-boot, which raises the mixture to the top of the building. From this elevator the mixture is conveyed in a rotary conveyor, in which the different ingredients are thoroughly mixed, to the rotary heater, consisting of a cylinder, 40 ins. in diameter and 21 ft. long, set at a slight inclination. By the revolution of this cylinder the mixture passes from the upper to the lower end and is thoroughly mixed thereby. The cylinder is heated to a temperature of about 80° C. by superheated steam introduced through a perforated pipe extending the length of the cylinder. This steam is superheated by the waste heat from the coke-breeze drier.

In this manner the several components have been accurately and uniformly proportioned, pulverized, mixed, and heated to a controlled temperature; also, a small quantity of water has been introduced, which is desirable to insure a pliant and readily moldable material for the press. In some processes a vertical cylinder with stirrers is employed instead of a horizontal rotating cylinder,

*A paper presented at the Pittsburg meeting of the American Institute of Mining Engineers, March 1-4, 1910.
†Syracuse, N. Y.

the mix being heated with superheated steam in a similar way.

ROTARY BRIQUETTE PRESS.—From the mixing cylinder the material is delivered by a short chute to the feed-box over the rotary press. The press used at this plant is of French manufacture and of the standard Belgian type. It consists of a heavy frame supporting two rolls, each of which carries in the middle a gear having 7-in. face and 2.5-in. pitch. On each side of the gears is a steel tire, 5.25 ins. wide on the face by 2.5 ins. thick. These gears and tires are accurately fitted on to the drum or roll, and keyed and bolted to place. The faces of the tires are hollowed out or cupped into recesses about 2.25 ins. long and 1⅞ ins. wide. There are three rows of these cups, arranged as close together as possible, so that each tire contains 207 cups. The rolls are accurately registered, so that the cuppings in two opposing tires shall produce the egg-shaped briquettes, the shape and dimensions of the cuppings determining the form and weight of the briquettes.

Provision is made for turning up the faces of these steel tires as they wear and for cutting out the cups, so that the life of the tires may be thereby prolonged. It is found that the wear is much greater with coke-breeze than with coal alone, and it is proposed to substitute rolls with chilled-iron faces in place of the steel. It has been found in our experiments that even the alloy-steels especially prepared to resist wear are not as satisfactory as chilled cast-iron. The cutting-action of the sharp particles of coke wears the best manganese steel, for example, perhaps even more rapidly than ordinary tool steel.

Adjustments are provided on the frame of the press which allow the rolls to be brought together as the tires wear or are dressed down. The rolls are driven by means of a pinion engaging one of the two gears. The pinion shaft in turn is driven through gearing by a belted motor. The belt affords a convenient safeguard in case of foreign material getting between the rolls and blocking them. If a direct drive is used, carefully designed breaking pins are essential.

The mix which has been delivered into the feed-box is constantly stirred therein by rotating paddles, and fed down to the rolls through two chutes, specially arranged with sides which may be moved in parallel, thereby controlling the feed of the mix to the rolls. It is essential to the production of uniform briquettes that, in addition to the mix being uniform in composition and temperature, the quantity delivered between the rolls must be accurately controlled, since it is the resistance of the material itself which determines the amount of pressure under which the briquette is produced.

From the press, the briquettes fall on a conveyor-belt and are delivered to a cooling conveyor outside of the building. This cooling conveyor is a slow-moving rubber belt of sufficient length to permit the briquettes to cool sufficiently so that the pitch will harden and give strength to the briquette to resist breakage as it passes through the screen and falls into the railroad car. At some plants the cooling conveyor is constructed of a woven wire belt, which would seem to be advantageous in that it gives greater access of air to all sides of the briquettes. When the briquettes have been sufficiently cooled to have acquired the necessary toughness, they are delivered from the cooling conveyor to a rotary screen, which separates out any fine material and knocks off any fins which may adhere to the briquette on account of wear of the rolls. From the rotary screen, the briquettes fall into railroad cars for shipment, or into storage piles. A small conveyor returns the fine unbriquetted material and the fins to the plant and delivers it back to the hammer mill, so that it is pulverized and thoroughly mixed with the new material.

Operating Results.

The capacity of this plant has not yet been fully developed. It has been brought up to 9 tons per hour, and it may reach 10 tons. The main features of the plant are, however, arranged to have a capacity equal to the output of two presses, and it is the purpose, as the market develops, to add the second press. This addition would result in a very material reduction in the cost of operation, since the labor required will be but little more than at present, about two more men. The power required for operating the elevators, conveyors, etc., and the repairs on these parts of the plant will be but little more than at present when the tonnage has been doubled. Probably the power required and the wear on the pulverizing mills, presses, and some other parts will be more nearly in proportion to the tonnage. An examination of the costs given below, based on the output of one press and two presses, shows very clearly the effect of output on the cost of briquette manufacture.

Repeated readings have been made of the power consumed in the different parts of the plant, with the following average result:

Motor Driving.	B. HP.
Breeze conveyor to drier	1.50
Breeze drier and ventilating fan	2.85
Pulverizing mill	22.00
Elevator shafting and rotary mixer	10.00
Briquetting press	25.00
Total	61.35

The press motor also drives the cooling conveyor, rotary screen, pitch cracker and conveyor.

The consumption of steam in the rotary heater and mixer depends partly upon the temperature of the atmosphere and partly upon the quantity of binder and its melting point. Tests at the Detroit plant, extending over a number of days, show a consumption of 206 lbs. of steam per ton of briquettes produced. This result was during a period of somewhat slow operation. No tests have been made during a period of steady running at full speed, but the above steam consumption per ton of product would undoubtedly be decreased by a larger output. The superheating of the steam is desirable in order to maintain it in a dry state, and prevent the addition of too much water to the mix. The experiment was tried of heating the outside of the rotary mixer and heater with a gas flame, but the use of superheated steam seems to be more satisfactory.

The labor on a plant similar to the one described is approximately:

	Cost per hour.
1 foreman	$0.50
1 pressman	0.26
1 oiler, breeze-drier and conveyor man	0.18
1 pitch man	0.18
1 briquette loader	0.19
2 laborers, at 17 cts.	0.34
Total	$1.65

When producing 9 tons of briquettes per hour, the labor cost becomes 18.3 cts. per ton. Two presses would double the output, but would only require two more men at 18 cts., and a second pressman at 26 cts. per hour, which would reduce the labor cost to 12.6 cts. per ton.

The use of coke-breeze increases the wear on all apparatus with which it comes in contact, but most especially on the briquetting rolls. The question to be determined in each case is whether the breeze can be obtained at a cost sufficiently low in comparison with coal to offset the increased repairs due to its use. In addition, coke-breeze has the advantage of being smokeless, so that its use reduces the smokiness of soft coal briquettes. The difference in cost of maintaining the briquetting rolls with and without coke-breeze is so great that two cost sheets are given below, which will illustrate the approximate cost of manufacturing briquettes under these two circumstances in a plant similar to that here described, producing 9 tons of briquettes per hour. If the plant were operated on the basis of the larger production obtained from two presses, it would be safe to estimate a reduction in these two costs of, say, 10 cts. per ton.

	Cost of briquetting per ton of product.	
	Using 50% of breeze.	Using 100% of coal.
Labor	$0.183	$0.183
Power, at 1.25 cts. per KW.-hr.	0.072	0.072
Steam, 206 lbs., at 0.5-ct. per HP.-hr.	0.034	0.034
Breeze-drier & superheater fuel	0.03	0.011
Miscellaneous supplies, oil, waste, lights and water	0.03	0.03
Repairs on rolls	0.191	0.035
Other repairs	0.06	0.035
Total	$0.60	$0.40

To obtain the total operating cost of a plant such as has been described, and operating under similar conditions, the cost of the pitch for binder and of the coal, coke-breeze, or other fuel used, must be added to these figures.

In order to have an illustration of such costs, let us assume that suitable slack coal can be obtained at $2, coke-breeze at $1, and pitch at $8 per ton, delivered at the plant. Since, as above pointed out, the use of breeze requires somewhat more binder, we will assume the use of 7.5% of binder with the coal and 9% with the mixture of coal and breeze.

	Cost of one ton of briquettes.	
	Equal parts of coal and breeze.	All coal.
0.455 ton coal, at $2	$0.91	....
0.925 ton coal, at $2	....	$1.85
0.455 ton breeze, at $1	0.455	....
9% of pitch, at $8	0.72	....
7.5% of pitch, at $8	....	0.60
Cost of briquetting, as above	0.60	0.40
Total	$2.685	$2.85

Many coals can be briquetted with less than the above quantities of pitch, and, of course, the costs of coal and coke-breeze vary at every plant, but the substitution of local prices in the above tables will give approximately the cost of briquettes in a plant having about the capacity of the one described. In larger plants the cost of operating is less, and with briquettes of large size for industrial purposes the cost would be materially reduced.

General Conclusions.

In contemplating the erection of a plant, not only must a press be selected suited to the material to be treated and also to the kind of briquette demanded by the available market, but it must be remembered that a briquette plant includes much more than the mere press. To insure economical operation, the preparation and handling of the material must be carefully studied and planned for, and the whole combination of driers, bins, elevators, measuring machines, crushers, mixers, heaters, conveyors, etc., must all be combined with the press into a single effective and economical unit, which will insure a uniform proportioning of the materials, their thorough and intimate mixture, their heating to a sufficient and uniform temperature, and their delivery to and removal from the press at a constant and reliable rate. If the various units entering into a briquette plant are thus successfully combined with careful economy of power and convenient arrangement, so that the labor is maintained at a minimum, a briquette plant should be a reliable and assured source of profit in locations where a satisfactory raw material and market for the product obtain. While the processes are simple and easily understood, it is essential that the different conditions be rigidly maintained, and usually it is only after the pressman and other more important operatives have attained certain instinctive recognition of the conditions that the plant becomes thoroughly successful.

Experience with Compounding and Superheating in the Locomotives of the Lancashire & Yorkshire Ry., England.

A paper was read March 17 before the Institution of Mechanical Engineers of Great Britain, describing the experience of the Lancashire & Yorkshire Ry., in the use of compound and superheating locomotives. The author of the paper, Mr. George Hughes, Chief Mechanical Engineer of the railway company, summed up the results of his experience by saying that on compound freight locomotives the saving of coal over ordinary locomotives was 9%. On superheating freight locomotives the saving was 12% and on superheating passenger locomotives the saving was 21%.

Compounding on the Lancashire & Yorkshire has been confined to freight locomotives. On passenger locomotives, Mr. Hughes believes there is very little gain in compounding. The advantage of expanding steam in two successive cylinders which is the essential feature of compounding, instead of in a single cylinder is of course due to the reduction of temperature range in the cylinders; but with the high piston speeds of fast passenger locomotives, there is not much time for the steam to condense and reevaporate in the cylinder. Further than this, the theoretical gain due to compounding is partially offset in a fast-running locomotive by the throttling of the steam in the ports at very high speeds, and excessive compression in the high-pressure cylinders.

For application to the freight locomotives of the Lancashire & Yorkshire, the four-cylinder compound system was adopted, the two high-pressure cylinders being placed outside and the low-pressure cylinders between the frames. Comparing two years' work of 11 compound and 11 simple locomotives of the same class, built in 1907, Mr. Hughes found that the compounds showed an economy in coal over the simple of 9.4% per ton-mile and 8.9% per train-mile. The compound locomotives made as large a mileage as the simple locomotives, and have thus far shown no heavier expense on repairs. Their first cost, however, was about $1,200 in excess of the cost of single locomotives. Mr. Hughes considers that at least three more years' experience will be necessary before the actual economy of the compound in coal and in maintenance can be definitely stated.

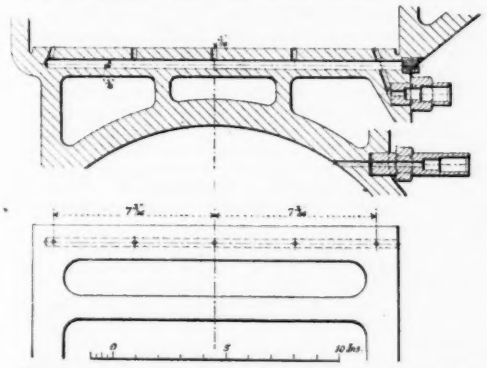
Mr. Hughes has been also experimenting with locomotives equipped with Schmidt superheaters, having built 20 freight locomotives and 5 passenger locomotives of this type. The freight locomotives show in regular service an economy in coal of about 12½% over the ordinary locomotives, and the superheater locomotives have made a much larger mileage. It appears that the service in which the superheater shows least advantage is a service where frequent stops are necessary, as in suburban traffic. If a stop lasts about four minutes, the temperature of the superheater elements drops to about that of superheated steam and have to be reheated after each stop before the gain from superheating occurs. Something similar occurs, also, on lines with irregular profile, where perhaps half the run is made with a closed throttle. The greatest

economy with superheating occurs in long-distance runs on roads with good grades, where the engine works continuously.

With the passenger locomotives, the coal economy obtained due to superheating is much greater than with the freight locomotives, amounting to about 21½% per train-mile over the simple locomotives. This greater economy is due to the fact that the passenger runs are made with less interruption for stops, for shunting, etc., than the freight runs.

No difficulty has been experienced in lubricating the locomotives using superheated steam, and this is probably due to the fact that special precautions have been taken to feed oil to the valve faces. This is such an important detail in the use of superheated steam that we reprint the following paragraph from Mr. Hughes' paper, and reproduce the illustrations to which it refers:

LUBRICATION.—For lubricating the valves, the cylinder port faces are provided with a number of small holes, fed by oil from a single pipe connected to a mechanical lubricator. To further ensure oil being properly distributed, the faces of the valves themselves have also several small holes. The piston-rods and valve-spindles have forced lubrication supplied to the steam side of the packing, also the cylinder barrel receives oil from the same lubricator. At first, cast-iron valves were used, but proving unsuitable, bronze valves were



Plan and Section of Valve Seat for Locomotives Using Superheated Steam, Lancashire & Yorkshire Ry., England. Showing Holes in Seat for Admission of Lubricant.

substituted. No undue heating has been experienced with either valves, pistons, valve or piston-rods, even with non-stop runs of 70 minutes, proving that air-cooled devices for metallic packing, as used in Germany and elsewhere, are not necessary when the method of lubrication is an efficient one. Both balanced and unbalanced valves have been tried on the Continent with doubtful success, probably due to some defect in the system of lubricating, but the method tried by the author proves that even unbalanced valves can be operated successfully under highly superheated steam, providing the lubricant is properly administered.

THE TORPEDO BOAT DESTROYER "PAULDING" was launched April 12 at Bath, Me. The "Paulding" has, in general, the same lines and equipment as the "Reid" and "Flusser," but she is the first torpedo boat destroyer in the U. S. Navy to be equipped exclusively with oil burners.

A BLAST IN A ROCK CUT on the Coleman-Texco extension of the Atchison, Topeka & Santa Fe Ry., near Coleman, Tex., on April 10, killed 14 men. The accident is ascribed to a misunderstanding or mistake in signals to the shot firer, which resulted in the blast being set off before all the men had left the cut.

THE COLLAPSE OF A CONCRETE ROOF under construction at the new car barn of the Shore Line Electric Ry. at Saybrook, Conn., on April 7, caused the death of the foreman, Jeremiah Keohane, of Suffield, Conn., and slightly injured two other workmen. The building is entirely of concrete, 74 × 194 ft. in plan with a middle longitudinal line of columns. The roof, a 4-in. slab of reinforced concrete, is carried on girders about 8 ft. c. to c. and spanning the 37 ft. from side walls to middle columns. The last work on the roof had been completed about 10 days on April 7, and the forms and their supports were being removed under the foreman's orders when it was noticed that the roof was settling at the end which had been completed last, and the foreman went out upon it to inspect it more closely. Before he could get off, but after most of the workmen had escaped from inside the barn, the roof slab and its supporting girder fell with the foreman and pulled a parapet wall down upon him. The other injured men were hit by falling pieces of concrete. The panels of the roof came down successively from the end last completed to the third panel from that end, all of which, both girder and slab, was in new concrete only about 10 days old. It is thought that the premature removal of the forms and also the excessive loading of the green roof with roofing material were the joint causes of the collapse.

A COMPLICATED RAILWAY WRECK near Rome, N. Y., April 8, on the New York Central & Hudson River R. R. blocked all four tracks for several hours. The accident occurred at 4 a. m. during a snow flurry. A westbound freight train stopped at a water plug a few miles east of Rome. A drill engine came up on the same track and stopped just behind the freight. In a few minutes, another westbound freight came up and collided with the switch engine, ramming it into the rear of the train ahead. Express train No. 33 then came along at about 45 mi. per hr. and side-swiped the wreckage. The fireman of the switch engine was the only one killed.

APRIL POWDER MILL EXPLOSIONS have already made their appearance as follows: The Corning mill at the Du Pont Powder Co.'s plant near Pittsburg, Kan., was destroyed by an explosion shortly after noon April 6. An unusual feature of this accident was the absence of fatalities. Three men were injured.

Press No. 1 of the Chattanooga Powder Co. at Coltewah, Tenn., was wrecked by an explosion April 8. Two men were killed.

A magazine of the Du Pont Powder Co., at Fulmer Valley, N. Y., exploded April 11, killing one man, an oil well shooter. The explosion is reported to have involved 800 qts. of nitroglycerine.

GRADUATES OF FRENCH ENGINEERING SCHOOLS are to be sent to this country by the French Government to work for two years each in bridge-building and mining plants. A commission of two French engineers, Jules Boenfve and Henri Vetillart, who have been appointed to find places for the graduates, arrived in New York City this week. Four students will be sent over each year and will work here for two years at a nominal salary, after which they will return to France in the service of the French Government.

PANAMA CANAL EXCAVATION during March totalled 3,067,479 cu. yds., a daily average of 117,980 cu. yds. for the 26 working days. The amount of concrete laid during the month was 90,502 cu. yds. and 571,293 cu. yds. of fill were placed. The rainfall for March was 3.78 ins.

A PILOT BOAT WAS SUNK April 11 off the Westlinder lightship near Ostend, Belgium, by collision with an unknown steamer. Nine men on the pilot boat were drowned.

THE DERAILMENT OF A PASSENGER TRAIN April 9 on the Atlantic Coast Line at De Leon Springs, Fla., is reported to have killed twelve persons and injured many others.

A passenger train on the Cleveland, Cincinnati, Chicago & St. Louis Ry. was wrecked by collision with a freight locomotive April 9 at Caledonia, Ohio. One man was killed. The collision is ascribed to a misreading of train orders.

A rear collision between a freight train and a light engine at Leavenworth, Wash., April 2, killed three men and injured three others. The freight train was backing out of a siding on to the main track when the light engine came up and crashed into the caboose. The men killed and injured were all in the caboose.

It is noticeable that several accidents reported this week involve locomotives running alone on main line tracks.

RAPID SHAFT SINKING.—In the 31-day period from the morning of March 3 to the morning of April 3, No. 1 shaft on the Moodna Siphon of the New York City Catskill Aqueduct, near Cornwall, was deepened 177 ft. The shaft was about 365 ft. deep on March 3. This is claimed by the contractors as a new record for American shaft sinking. The shaft is circular, with a minimum allowable radius of 7 ft. 11 ins. and an average diameter of about 16 ft. 8 ins. The shaft was sunk with one eight-hour drilling shift and two eight-hour mucking shifts daily. Thus 19 shifts were worked per week, two being lost on Sundays. The rock penetrated was hard Hudson River shale. A liberal bonus is stated to have contributed to the progress shown. Mr. Walter Steenburgh was in charge of the work described, under the general supervision of Mr. Francis Donaldson, Chief Engineer for the contractor, the Dravo Contracting Co.

A NEW AEROPLANE RECORD.—It is reported that one Daniel Kinet, a Belgian, made a record flight in an aeroplane with one passenger by staying up for 2 hrs. 20 min. at Chalons, France. The type of aeroplane is not reported.

The International Aviation Trophy won last year in France by Glenn H. Curtis will be contested for in 1910 in this country, as the result of an agreement between the Aero Club of America and the Wright Company owner of the aeroplane patents of Orville and Wilbur Wright. The club recognizes the right of the company and agrees to refuse to countenance any infringement of them. The club agrees to approve only such public contests as are sanctioned by the Wright Company. The company, on the other hand, agrees to willingly grant licenses to any promoters who will guarantee compensation for the use of patent rights on any competing machines which it may be desired to exhibit and enter.

UPPER BERTHS IN PULLMAN SLEEPING CARS are to cost less than lower berths on several railways in the Northwest hereafter, according to an Interstate Commerce Commission ruling. The Commission finds that the Pullman company has practically doubled its capitalization and dividends in the past eleven years without investing any new capital.

A SPEED OF 41.4 MILES PER HOUR for four hours was made last week by the U. S. torpedo boat destroyer "Reid" over a trial course off the Florida coast of the Gulf of Mexico. This 36-knot speed is the record for any naval vessel. A board of naval inspectors is now engaged in an inspection test of the five boats of this class which are about to be commissioned. All of the boats maintained high speeds, especially the 'Flusser," which made 35 knots over the four-hour trip, but the "Reid" showed about a knot better speed than the best of the others.

In our issue of Oct. 14, 1909, p. 400, we reported the first speed test of the "Reid" when she made 34.548-knot speed over a measured mile. Just before that (Sept. 16, 1909, p. 313) we reported that the "Flusser" had made 33.7 knots over a measured mile. When made each of these were record speeds. These boats are 295 ft. long and have a tonnage of 700 tons.

THE STEEL FRAMEWORK of a car barn in the course of construction for the Northern Indiana Ry. at South Bend, Ind., blew down in a heavy gale on April 6, and seriously injured four workmen.

THE TRANS-ANDINE TUNNEL WAS OPENED on April 5, with official representation of both Argentina and Chile.

A PECULIAR BASCULE BRIDGE ACCIDENT occurred on April 8 at the Fort Point Channel bridge of the New York, New Haven & Hartford Ry. A suburban train had crossed the bridge but was held just beyond by a danger signal. The draw was opened for a vessel, and the overhead portal girder connecting the tail-pieces of the trusses came down on the roof of the last car, breaking the roof and injuring several occupants of the car. Apparently the latch of the bridge was not locked by track-circuit, at least not for a sufficient length.

Personals.

Mr. H. R. Safford, M. Am. Soc. C. E., Chief Engineer of Maintenance of Way of the Illinois Central R. R., has resigned and will enter the railway supply business.

Mr. H. Berlin Voorhees, Superintendent of the Philadelphia division of the Baltimore & Ohio R. R., has been appointed First Assistant to the President, Mr. Daniel Willard.

Mr. G. H. Herrold has been appointed Engineer of Maintenance of Way of the northern division of the Chicago Great Western R. R., with headquarters at St. Paul, Minn. He succeeds Mr. M. A. Zook, transferred.

Mr. S. Sakuragi, a Japanese director of the South Manchuria Ry., with headquarters in Dalny, Manchuria, has arrived in New York City, where he will make a study of systems of handling and housing cargoes at the docks.

Mr. H. L. Laughlin, formerly Engineer of Maintenance of Way of the Minneapolis, St. Paul & Sault Ste. Marie Ry. for many years, has recently become Chief Engineer of the Twin City & Lake Superior Ry. (electric), of Minneapolis, Minn.

Mr. J. H. Blair, formerly Chief Engineer of the Southwestern Bridge Co., of Joplin, Mo., and Mr. S. T. Davis, a general contractor, have formed a partnership under the firm name of Davis & Blair, general contractors, with offices in Pittsburg, Kan.

Mr. Quincy A. Shaw has become President of the Calumet & Hecla Mining Co., succeeding Alexander Agassiz, whose death was noted in our issue of March 31. Mr. R. L. Agassiz, a son of the former president, has been made Vice-President of the same company.

Mr. W. J. Rusling, Assistant Master Mechanic of the Pennsylvania R. R. at Harrisburg, Pa., has been pro-

moted to the position of General Foreman of the Enola shops. Mr. H. G. Huber, formerly Assistant Master Mechanic at Phillipston, Pa., will succeed Mr. Rusling at Harrisburg.

Mr. Philip B. Woodworth, Dean and Professor of Electrical Engineering at Lewis Institute, Chicago, has associated himself with Rummler & Rummler, patent lawyers, Chicago. He will give special attention to applications for patents on electrical inventions and to consultations in suits involving electrical matters.

Mr. F. W. Williams, Superintendent of Motive Power of the Chicago, Rock Island & Pacific Ry. at Fort Worth, Tex., has been transferred to Cedar Rapids, Iowa, and the territory formerly under his control has been included in that under the jurisdiction of Mr. C. M. Taylor, Superintendent of Motive Power at Shawnee, Okla.

Obituary.

Kirk P. Crandall, a civil engineer, died April 7, at Ithaca, N. Y., aged 64 years. He surveyed the Northern Pacific Ry.'s line through North and South Dakota and was connected with the construction of other railways in the West and in South Africa and Chili. He was for a time engaged in reclamation work in the Florida Everglades. Kirk Crandall was a brother of Professor Chas. L. Crandall, M. Am. Soc. C. E., of Cornell University.

Alfred Kimber, M. Am. Inst. M. E., Mining Engineer of Ladenburg, Thalmann & Co., and a member of that firm, died April 6 from blood poisoning. Mr. Kimber was born in England in 1846 and was educated at King's College, Oxford. Upon coming to this country in 1863, he went first to the Pacific Coast and became interested in mining projects. He came to New York City in 1880 and bought a seat on the stock exchange which he held until 1895 when he entered the firm of Ladenburg, Thalmann & Co. Mr. Kimber was a member of the Engineers' Club of New York City.

Emory V. Donelson, formerly Electrical Commissioner of Baltimore, Md., died in that city April 5 while on the way from his home to his office. Mr. Donelson's term as Electrical Commissioner covered the period of installation of new equipment following the conflagration in 1904. At the time of his death, he was the district representative in Baltimore of the Asbestos Protected Metal Co., of Canton, Mass.

Franklin R. Carpenter, M. Am. Inst. M. E., a prominent metallurgist and geologist, died April 1 in Chicago, Ill. He was born at Parkersburg, W. Va., in 1848 and was a graduate of Ohio University. He went to Colorado soon after graduating and was at first a school teacher in Gilpin Co. After a brief period during which he was interested in politics, running twice for superintendent of public instruction, he took up the study and profession of mining engineering.

He removed to South Dakota in 1886 and became Dean of the South Dakota State School of Mines. After three years in this position, he went to Deadwood and constructed there the Deadwood & Delaware smelter. He was the inventor of the pyritic system of smelting, which is still largely used in the Black Hills region. During his sojourn in South Dakota he wrote a book on "Geology of the Black Hills." He returned to Colorado in 1900 and built and operated for some years the Carpenter smelter at Golden.

Dr. Carpenter is survived by his wife, a daughter and four sons. Recently his sons have been in business with him under the firm name of the Franklin R. Carpenter Co., at Denver, Colo.

Edward W. Gilmore, Secretary and Treasurer of the Fairchild, Gilmore, Milton Co., paving contractors, of Los Angeles, Cal., died in that city March 31 aged 60 years. His death occurred in his office in the Pacific Electric Building. Mr. Gilmore was born in Wisconsin. Before going to Los Angeles, he made his residence for a time in Tacoma, Wash., where he organized and was President of the Tacoma Bituminous Paving Co.

Thomas F. Walsh, M. Am. Inst. M. E., the discoverer and principal owner of the Camp Bird gold mine at Ouray, Colo., died April 8 at his home in Washington, D. C. Mr. Walsh was born in Tipperary Co., Ireland, in 1851 and received there a common school education. He came to America at the age of 19 and worked first as a day laborer on the streets of Boston and then as a carpenter. After a few years in Massachusetts, he went to Colorado and became a contractor, soon acquiring a comfortable fortune. He built and managed a large hotel at Leadville, Colo., and later another one at Ouray.

He took up the study of practical geology, metallurgy and mineralogy and developed a genius for mine prospecting which by 1887 had put him in a position to retire, but an unfortunate investment at about this time very nearly wiped out his entire fortune. He began again a successful career as a miner which culminated in his discovery and development of the Camp Bird mine. In 1900 he was appointed by President McKinley as a commissioner to the Paris exposition, and while in Paris he made the acquaintance of the late King Leopold, of Belgium, with whom he was subsequently associated in various mining ventures in America.

The Walsh fund for the examination of radium-bearing ores was established by Mr. Walsh in 1909 at the Colorado State School of Mines. He was President of the National Irrigation Congress in 1906 and of the Aero Club of Washington in 1909. He was a member of the American Association for the Advancement of Science, the Washington Academy of Sciences, the National Geographic Society and of prominent clubs in Denver, Colorado Springs, Washington and New York City.

Engineering Societies.

COMING MEETINGS.

AMERICAN WATER WORKS ASSOCIATION.
April 26-30. Annual convention at New Orleans, La. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 5-7. Annual meeting at Pittsburg, Pa. Secy., Jos. W. Richards, South Bethlehem, Pa.

APPALACHIAN ENGINEERING ASSOCIATION.
May 6-7. Annual meeting at Winston-Salem, N. C. Secy., Henry M. Payne, Morgantown, W. Va.

AIR BRAKE ASSOCIATION.
May 10. Annual meeting at Indianapolis, Ind. Secy., F. M. Nellis, 53 State St., Boston, Mass.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
May 16-29. Annual meeting at Los Angeles, Cal. Secy., P. W. Drew, Room 306, 135 Adams St., Chicago, Ill.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 17-19. Annual meeting at Chicago, Ill. Secy., Franklin H. Wentworth, 87 Milk St., Boston, Mass.

AMERICAN RAILWAY ASSOCIATION.
May 18. Annual meeting at New York City. Secy., W. F. Allen, 24 Park Pl., New York City.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
May 19-20. Semi-annual meeting at Cincinnati, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 23-26. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, 327 La Salle Station, Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 23-28. Annual meeting at St. Louis, Mo. Secy., T. C. Martin, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF ARCHITECTS.—The next annual convention will be held in San Francisco, Cal., some time between Jan. 15 and 30, 1911.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—At its meeting of April 5, the board of directors adopted the following resolutions regarding the licensing of engineers in the State of New York as proposed in the bill promoted by Mr. E. J. L. Raldiris:

Resolved, That it is the sense of the Board of Direction that it is the duty of the American Society of Civil Engineers to use its influence in the proper formulation of all legislation by the General Government, or by any of the States of the Union, which affects the practice of engineers; and the board recommends the appointment by the society of a committee whose duty it shall be to formulate the general lines on which such legislation shall be based, and that said committee be requested to report at the next annual convention.

At the regular meeting of the society on April 6, in New York City, a resolution was passed providing for the appointment by the president of four members to act with him as a committee of five to consider the matter of such legislation, as outlined in the resolution of the board and present a report at the annual convention in Chicago, June 21-24.

At the meeting of the San Francisco Association of members of the American Society of Civil Engineers April 15, Mr. H. H. Wadsworth will present a paper on "The Failure of the Yuba River Debris Barrier." Papers published in the February "Proceedings" will be discussed by the members at this meeting.

WATER WORKS MANUFACTURERS' ASSOCIATION.—The annual meeting will be held at the Grunewald Hotel, New Orleans, La., April 26, during the annual convention of the American Water Works Association.

AMERICAN WATER WORKS ASSOCIATION.—The program for the 30th annual convention at New Orleans, La., April 26-30, includes the following: April 26: Reports of standing and special committees on Electrolysis, Fire Protection, Water Works Standards, Depreciation, Reorganization and on Uniform Annual Reports and Accounts; "The Use of Electricity in Water Works Pumping," Chas. B. Burdick; "Brief Review of Some of the Recent Public Improvements in New Orleans," an informal talk by Geo. G. Earle, General Superintendent of the New Orleans Sewerage and Water Board. Mr. Earle's lecture, illustrated by lantern slides, will be given at the evening session and will be followed by dancing and light refreshments.

April 27: "Legal Decisions Concerning Setting of Meters and Meter Rates at Anniston, Ala.," H. B. Rudisill; "Care of Meters and Method of Handling Them in Service," A. W. Cuddeback. The election of officers will be held at 11 o'clock. The afternoon will be devoted to a trip to the city pumping station and filter plant and in the evening Mr. Allen Hazen will present a paper on "The New Water-Supply of Springfield, Mass."

April 28: "Conservation of Potable Waters," J. M. Diven; "The Cost of Furnishing Water," Daniel W. Mead; "A Cooperative Water Works Franchise," John W. Alvord; "Municipal Ownership," Park Woodward; "Baltimore County Ozonation Plant," A. E. Walden. An excursion on a river steamer will occupy the afternoon and theater parties the evening.

April 29: "A Railway Episode," Willis B. Durlin; "Action of St. Louis Water on Metals and Alloys," Wilson F. Montfort; "Danger of Contaminating Water-Supply by Back Pressure from Fire Pumps," Alexander Milne; "Suggestions for Water-Works Efficiency in Fire Protection," W. H. Glore; "Water Softening," Alexander Potter; "Advertising the Water-Works Business," Dow R. Gwinn; "The Construction and Operation of the Settling Basins at Richmond, Va.," E. E. Davis; "The Fire-Service Water Works of Winnipeg," H. N. Ruttan.

BOSTON SOCIETY OF CIVIL ENGINEERS.—A special meeting, conducted by the sanitary section, was held March 30, at the Boston City Club for discussion of the garbage disposal problem. Fifty-five members of the society and sanitary section, with guests, were present. The principal paper was presented by Col. William F. Morse, of New York City, who reviewed the history of the disposal of garbage and refuse both in this country and abroad, beginning with the original simple forms of crematory furnaces and extending to the modern types of reduction and destructor plants. A large number of lantern slides were shown to illustrate the construction, operation and results obtained at such plants, special attention being paid to those at New Bedford, New York, Schenectady, Cleveland, Seattle, etc., in this country.

Col. Morse is very sanguine with respect to the present status of garbage disposal and believes that garbage properly utilized should turn a profit into the pockets of taxpayers, and that in this case the protection of the public health goes hand in hand with the protection of the public pocketbook. He believes that the whole question is an engineering one and its satisfactory solution and application to municipalities must be brought about through the efforts of engineers rather than other city or town officials. In his opinion, the results obtained with such plants as at Cleveland and Seattle indicate that although the first expense of a disposal plant may be high, yet with skill and care in operation in the course of a few years it can be made to not only be self-supporting, but to afford some revenue.

The dangers connected with the reduction process were forcibly dwelt upon by Col. Morse, it appearing that almost without exception every plant of this class in the country has been either burnt or blown up, and there is evidently much opportunity for improvement in safety of operation.

The collection of garbage is almost always accomplished in an inefficient and unsanitary manner, and the use of special collecting carts so arranged as to be practically gas tight and odorless, such as have been designed under the supervision of Mr. E. S. Dorr, of the Boston Street Department, is one of the important requisites of modern treatment of garbage.

Mr. Willis C. Merrill, Manager of the New England Sanitary Waste Disposal Co., of Boston, followed Col. Morse. Mr. Merrill is inclined toward the use of the reduction process, rather than that of the destructor, in garbage disposal, from the general viewpoint of conservation of the various by-products. He does not feel that the methods and processes have been sufficiently perfected at this time to result in an element of profit, but that garbage disposal even now can be satisfactorily accomplished at low cost and the future will likely bring about such improvements as will enable the work to be done so as to produce some revenue.

Mr. Charles S. Wheelwright, of Providence, expected to join in the discussion, but was prevented on account of illness.

Mr. Guy C. Emerson, Superintendent of Streets, of Boston, spoke briefly with special reference to the garbage disposal problem in Boston. He believes that garbage disposal in this city can only be effected at some considerable cost, basing his conclusions on a study of some of the plants in this country, notably those at Montreal, New Bedford and Seattle. Thus, at the Montreal plant where it is contended that garbage is being disposed of with profit, Mr. Emerson has concluded after investigation that the profit was largely a matter of bookkeeping and that if all items properly chageable to the reduction plant were taken into account it would be found that even here considerable expense was being incurred. In Boston, moreover, the conditions in respect to the location of a disposal plant would be much more difficult than in Montreal, as in the latter place it was possible to obtain a location at no very great distance from the city, which would not be the case in Boston. The disposal of clinker for use in making concrete he considered to be largely affected by the local conditions in respect to procuring gravel and sand, and in the vicinity of Boston, where such material is readily obtained for making concrete, the clinker from the furnace would not be an element that could be disposed of to advantage.

The general opinion of the meeting seemed to be unified in respect to the present status of garbage disposal—that it is an engineering problem that must be taken up, studied and solved for each locality by competent sanitary engineers.—H. K. Barrows.